American
POTATO JOURNAL

Volume 36 *August 1959* *Number 8*

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Official Publication of

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American Potato Journal

PUBLISHED BY

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NEW BRUNSWICK, N. J.

Price $4.00 per year in North America; $5.00 in other countries.
Not responsible for free replacement of non-delivered or damaged issues after 90 days.

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

TAWA: A NEW EARLY POTATO VARIETY RESISTANT TO LATE BLIGHT, SCAB, AND IMMUNE TO LATENT MOSAIC[1]

C. E. PETERSON[2] AND W. J. HOOKER[3]

On June 11, 1956, the United States Department of Agriculture, in cooperation with the Iowa and Michigan Agricultural Experiment Stations, announced the release of a new potato variety named Tawa[4]. This is the first variety combining resistance to late blight and scab with a high degree of resistance approximating immunity to virus X. Tawa matures early and produces smooth attractive tubers with good cooking and chipping quality.

ORIGIN

The cross from which Tawa was derived (Iowa 803) was made in the greenhouse at Iowa State College, Ames, Iowa, early in 1948 and the seeding plants were grown in the same greenhouse in the fall of 1948. Before transplanting to 3-inch pots in the greenhouse bench, the small seedling plants, in flats, were inoculated with both late blight and virus X. Those plants showing resistance to late blight and no symptoms of virus X were transplanted. Plants were inoculated once again with virus X after transplanting and all individuals developing symptoms were discarded. A population, in which more than 90 per cent of the individual plants were immune to virus X (*7*) and resistant to race *0* of late blight, was obtained.

The seedling tubers from the greenhouse were planted in muck soil on the farm of Sam Kennedy and Sons at Clear Lake, Iowa, in 1949. From a relatively small progeny of only 50 hills from this cross, 3 were selected and tested for horticultural qualities. Of these Iowa 803-3 appeared most promising. The pedigree of Iowa 803-3 is shown on page 268.

DESCRIPTION OF TAWA

PLANTS:—medium to large, spreading. *Stems*: Medium thick, angled. *Nodes*: Slightly swollen, green. *Internodes*: Green. *Wings*: Single, straight, green. *Stipules*: Medium large, green, scantily pubescent, spreading. *Leaves*: Long, broad, medium open. *Midribs*: Green, scantily pubescent. *Terminal leaflets*: Occasionally lobed on lower leaves. *Primary leaflets*: Ovate, close, green, three pairs generally large with small to medium fourth pair, mean length 65.0 ± 0.67 mm. (2.56 in.), mean width 40.7 ±

[1]Accepted for publication November 3, 1958. Journal Paper J-3493 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Journal Paper No. 2282 of the Michigan Agricultural Experiment Station, East Lansing, Mich. Cooperative work with the National Potato Breeding program of the United States Department of Agriculture, Beltsville, Md.

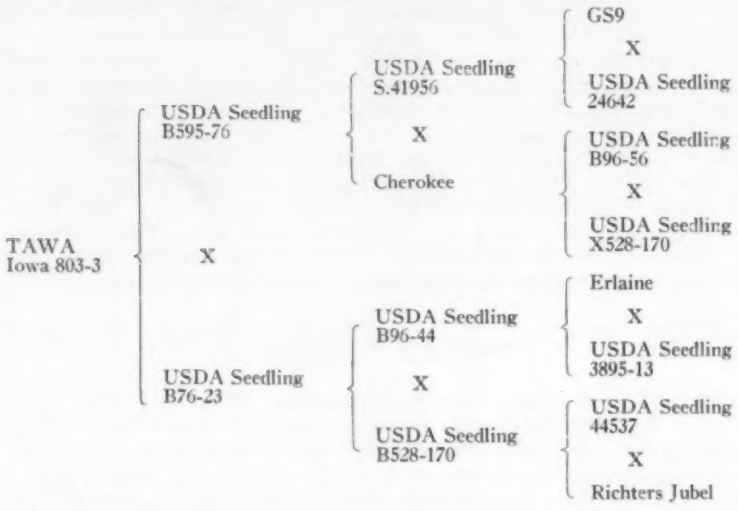
[2]Professor, Department of Horticulture, Michigan State University.
[3]Professor, Department of Botany and Plant Pathology, Michigan State University.

[4]Shortened form for Ottawa, one of the most important Indian tribes of Michigan from which Tawas City, Michigan, and Tawas Bay derive their names.

0.46 mm. (1.6 in.), index 62.7 ± 0.38.[5] *Secondary leaflets*: Few. *Tertiary leaflets*: Few to none. *Inflorescence*: Medium to little branched. *Leafy bracts*: None. *Peduncles*: Long, green, scantily pubescent. *Pedicels*: Medium in length, scantily pubescent, green.

FLOWERS:—*Calyx lobe tips*: Irregular medium to short, green, scantily pubescent. *Corolla*: Medium in size, white. *Anthers*: Lemon yellow. *Pollen*: Sparse, poor quality. *Style*: Medium length, straight. *Stigma*: Globose, mostly 2 and 3 lobed, green.

TUBERS:—predominantly short, elliptical, smooth, thick, mean length 84.5 ± 0.57 mm. (3.33 in.), mean width 78.1 ± 0.32 mm. (3.07 in.), mean thickness 65.8 mm. ± 0.42 mm. (2.59 in.);[6] indices—width to length 95.0 ± 0.8,[7] thickness to length 79.0 ± 0.9,[8] thickness to width 83.0 ± 0.6;[8] *Skin*: Smooth dark creamy-buff, considered white in commercial trade. *Eyes*: Shallow, same color as skin. *Eyebrows*: Medium length, curved, not prominent. *Flesh*: White. *Maturity*: Early.

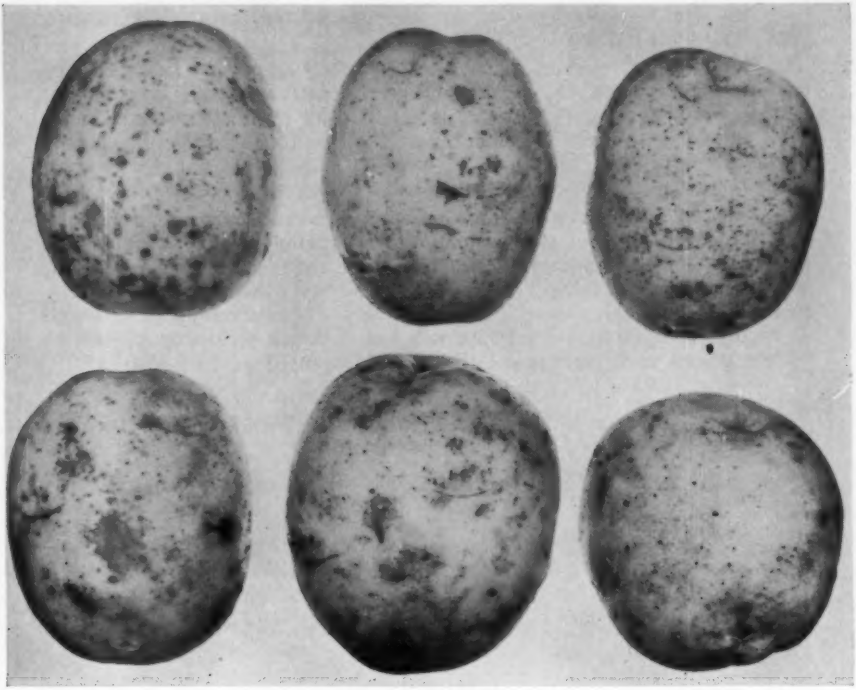


[5]Calculated by dividing the width of each of 100 leaflets by their length, and multiplying the average of these ratios by 100. The leaflets were taken from the fourth leaf from the top of the stem, one leaflet (the distal left lateral) being taken from each leaf. Since the potato leaflet is asymmetrical the length was determined by taking the average of the measurements from the apex to the base of each respective lobe. This is a modification of the method described on pages 163 to 170 of Salaman's Potato Varieties (6).

[6]Average measurements of 100 tubers each weighing approximately 8 ounces.

[7]Calculated by dividing the width of each of 100 tubers by its length and multiplying the average of these ratios by 100. The data used for calculating the indices were taken from the same measurements as used to designate the dimensions of the tubers.

[8]Based on the measurements of the same tubers as used for determining the width to length index and with the same methods of calculation.



Disease Resistance

Tawa is resistant to scab incited by *Streptomyces scabies* (Thaxt.) Waksman and Henrici. The degree of resistance is not so high as that of Ontario, Cayuga, or Menominee but it is considerably higher than that of Sebago and will be of use where scab is a problem.

This variety possesses the "immune" type of resistance to virus X similar to that of S.41956. No symptoms are expressed on leaves of Tawa following mechanical inoculation with a strain of the virus which produces severe symptoms of mottle and necrosis on susceptible potato plants free of virus X, *Datura stramonium*, and *Nicotiana glutinosa* (4).

Tawa stocks, when grafted with virus X infected scions of Cobbler after the method of Raleigh (5), respond by formation of aerial tubers above the graft union. Virus X was not recovered from leaves of plants inoculated either by leaf rubbing or by grafting. Virus X has been recovered from roots, and underground portions of Tawa as well as from S.41956 and Saco, Benson and Hooker (2).

Tawa is resistant to the race *0* of *Phytophthora infestans* (Mont.) de

Bary (1) and to at least one of the other specialized races of the fungus. Field resistance has not been evaluated.

Tawa is also resistant to virus A. Repeated attempts to establish infection with virus A, using graft inoculation methods, have been unsuccessful. No symptoms of virus A infection were produced and the virus could not be recovered from such plants. Apparently this variety possesses a very high type of resistance to virus A. There is no hypersensitive reaction to virus A suggesting the presence of the gene Na, Cockerham (3).

Tawa may be somewhat more resistant to Verticillium wilt than most commercial varieties of similar maturity in Michigan. Late varieties are generally more tolerant of Verticillium wilt than early ones. Although wilt was severe in Idaho, Tawa was less severely wilted than other varieties of the same early maturity class (Table 1).[9] Tawa cannot be classified as highly resistant to Verticillium wilt but it is not so susceptible as the widely grown early varieties Early Gem, Triumph, or Red Warba.

TABLE 1.—*Incidence of Verticillium wilt in Tawa and in other varieties in Idaho field trials.*[9]

	Aberdeen		Rexburg	
	1954	1955	1954	1955
Tawa	28.3	48.0	37.0	71.7
Early Gem	40.0		60.0	
Triumph	65.0	75.0	75.0	80.0
Red Warba	68.3			

YIELD AND MARKET QUALITY

The first replicated yield trial of Tawa was conducted on muck soil at Clear Lake, Iowa, in 1952 (Tables 2 and 3). The year 1952 was an exceptionally fine growing season for potatoes. Tawa yielded very well considering its early maturity. Total solids were high and defects, both internal and external were low.

Because of a shortage of seed in 1953 and floods in 1954 the variety could not be tested again in Iowa until 1955. The season 1955 was very hot and dry. Under such conditions Tawa showed a tendency to develop scab and growth cracks.

In Michigan and Wisconsin during 1954 and 1955 Tawa showed sufficient promise in widely scattered areas, particularly on muck soil, to justify its release. The most outstanding performance in trials in 4 mineral and 2 muck soils in Michigan was on the muck soil in Allegan County in 1955 where Tawa yielded 592 bushels of US No. 1 potatoes compared with 117 bushels for Cobbler (Table 4). In this trial under hot, dry conditions and in a severely scab infested field, Tawa produced 83

[9]Data from John G. McLean. Indices computed by giving values of 10 for slight, 30 for moderate, 50 for severe, and 100 for dead plants and dividing total by number of plants.

TABLE 2.—*Performance of Tawa in comparison with other potato varieties on muck soil at Clear Lake, Iowa, 1952.*

Variety	Yield of U.S. No.1 Bu./A.	Total Solids[1] Per cent	Maturity[2]	Internal Defects[3]			
				Hollow Heart Per cent	Internal Necrosis Per cent	Vascular Discoloration Per cent	Normal Tubers Per cent
Sebago	782	18.8	4+	0	12	1	87
LaSoda	653	16.7	3	0	2	0	98
Ontario	600	18.4	5	1	38	0	62
Tawa	518	18.6	2	1	1	4	95
Cobbler	487	18.5	2	18	1	6	76
Kennebec	475	18.6	4	5	0	0	95
Pontiac	449	16.4	3	2	1	4	93
Progress	369	19.7	3	0	3	0	97
LSD	116[4]	0.6[4]					
LSD	153[5]	0.8[5]					

[1]Total dry weight in per cent determined by the specific gravity method.
[2]Maturity: 1, Earlier than Cobbler; 2, Cobbler maturity; 3, Pontiac maturity; 4, Katahdin maturity; 5, Later than Katahdin.
[3]Based on 5 20-tuber samples expressed in per cent by number. Samples for cutting were U. S. No. 1 in external appearance. Some tubers had more than 1 internal defect.
[4,5]L.S.D. at p 0.05 and 0.01, respectively .

TABLE 3.—*Performance of Tawa in comparison with other potato varieties on muck soil at Clear Lake, Iowa, 1952.*

Variety	Under size	Scab		External defects[1]			
		Culls	Area and Type[2]	Growth Cracks Per cent	Second Growth	Sun-green	Total Defects
	Per cent	Per cent			Per cent	Per cent	Per cent
Sebago	3.5	0.1	1-2	0.4	0.0	1.5	5.5
LaSoda	3.8	9.1	1-4	3.3	3.7	2.3	22.2
Ontario	5.4	1.0	T-1	0.3	4.1	0.0	10.8
Tawa	6.5	0.0	1-1	1.3	0.4	0.8	9.0
Cobbler	8.2	5.4	1-3	0.9	9.4	0.6	24.5
Kennebec	3.3	1.2	1-3	14.2	5.4	4.2	28.3
Pontiac	3.8	5.7	1-3	29.0	0.9	0.1	39.5
Progress	5.9	35.7	2-4	3.2	0.8	0.4	46.0

[1]Mean grade defects from 5 replications expressed in per cent by weight.
[2]First figure indicates area: T = trace; 1 = 1-20 per cent of area covered; 2 = 21-40 per cent of area covered. Second figure indicates type of scab lesions: 1 = Surface russet type; 2 = raised surface or shallow pit; 3 = Deep pit; 4 = Very deep-pitted scab.

per cent US No. 1 grade whereas Cobbler produced only 21 per cent of U.S. ones.

In variety demonstrations at 3 locations in Wisconsin in 1955 and 1956, the percentage of US No. 1 potatoes was higher with Tawa than

TABLE 4.—*Yields and total solids of Tawa in comparison with other potato varieties on two soil types in Michigan, 1955.*[1]

Soil Type, County, and Nature of Data	Variety					LSD	
	Tawa	Early Gem	Cobbler	Wasec:	Chero-kee	P=0.05	P=0.01
Muck Soil							
Allegan							
U.S. No. 1 yield (Bu./A.)	592	146	117	407	156	159	213
Total solids (Per cent)	14.3	13.2	15.7	13.8	17.2	1.2	1.6
Arenac							
Total yield (Bu./A.)	98	27	72	110	51	43	58
Total solids (Per cent)	16.2	13.6	15.3	14.5	16.9	0.8	1.2
Mineral Soil							
Montcalm							
Total yield (Bu./A.)	230	267	273	210	153	108	144
Total solids (Per cent)	16.7	14.3	16.0	13.8	15.3	1.4	2.0
Menominee							
Total yield (Bu./A.)	324	357	364	336	317	74	99
Total solids (Per cent)	18.4	16.3	18.6	16.0	19.7	N.S.	N.S.
Emmet							
Total yield (Bu./A.)	94	96	109	116	100	N.S.	N.S.
Total solids (Per cent)	15.7	12.4	14.9	12.2	14.0	1.4	1.8
Bay							
Total yield (Bu./A.)	200	289	205	272	219	N.S.	N.S.
Total solids (Per cent)	16.7	13.6	15.7	13.6	16.9	1.0	1.4
Average (Mineral Soil)							
Total yield (Bu./A.)	212	252	238	234	197	42	56
Total solids (Per cent)	16.9	14.0	16.2	13.8	16.5	1.2	1.8

[1]Data from Dr. D. R. Isleib, Department of Farm Crops, Michigan State University, East Lansing, Mich.

with any of the other varieties (Table 5). As was the case in the 1955 Michigan trials, Tawa showed the greatest promise on muck soils.

No advantage in yielding ability can be claimed for Tawa under conditions where Cobbler produces a high percentage of US No. 1 tubers. Tawa is recommended for trial by growers who are experiencing difficulty producing Cobbler or other early varieties because of scab, late blight, or various external and internal grade defects.

In a few cases growth cracks have resulted in rather heavy loss in grade. In all trials some growth cracking has been reported, but in nearly all cases it has not been serious and is often less severe than in some of the widely grown standard varieties.

Sun greening, resulting from tubers being set close to the surface, has been reported but can be overcome by adequate hilling. Some harvest cracking has been reported where immature tubers are subjected to rough handling at harvest. This can be reduced by exercising care in the harvesting operations.

TABLE 5.—*Total yield, percentage of US #1 tubers, and total solids of seven varieties tested in Wisconsin, 1955 and 1956.*[1]

Variety	Hancock Sand						Spooner Sand						Sullivan Muck					
	1955			1956			1955			1956			1955			1956		
	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent	Yield Bu./A.	U.S. No. 1 Per cent	Total Solids Per cent
Tawa	397	90	18.7	591	83	18.7	337	96	17.2	461	86	19.6	324	93	15.4	443	85	18.5
Cobbler	384	82	18.7	..	..	..	364	70	17.4	..	..	..	..	..	..	..	..	..
Early Gem	296	70	15.8	454	72	16.5	332	88	14.3	407	67	17.8	337	87	14.0	357	75	16.0
Cherokee	318	73	19.4	..	..	..	..	..	..	371	71	20.2	370	78	18.3	..	..	..
Chippewa	433	81	16.7	630	76	16.7	499	85	16.3	584	81	17.8	421	75	14.3	475	80	15.4
Red Pontiac	482	81	15.0	674	77	16.9	583	88	15.0	614	80	17.4	566	75	14.5	421	65	15.4
Red Warba	376	86	17.4	380	59	18.0	193	61	17.4	449	75	18.3	..	..	..	..	..	..

[1]Data from John A. Schoenemann, University of Wisconsin, Madison, Wis.

Cooking and Chipping Quality

In content of total solids and geenral cooking quality Tawa is equal to Cobbler (Tables 2, 4, and 5). Tawa proved to be a satisfactory variety for chipping both at harvest and after conditioning (Table 6). In this respect, it is apparently superior to Cobbler and Cherokee, but not quite so good as Russet Rural or Kennebec.

Distribution

Foundation seed was distributed to certification officials in most of the important certified seed-producing states. Seed was increased on a small scale in 1956 and 1957 in Minnesota, Maine, South Dakota, Wisconsin, Michigan, Nebraska, Montana, New York, Oregon, and Colorado. Sources of certified seed can be secured from certifying agencies in these states. No seed is available for sale or free distribution from the Iowa or Michigan Agricultural Experiment Stations or the USDA. By 1960 seed of Tawa should be available for general distribution through the regular state organizations in seed producing states.

Table 6.—*Comparison of Tawa with other varieties in chipping quality based on color of chips.*[1]

Variety	Color Rating				
	1950			1951	1953
	Harvest	2 weeks[2]	4 weeks[3]	2 weeks[3]	25 days[5]
Tawa	2.1	3.8	2.9	2.8	1.0
Cobbler	2.2	3.5	3.0	3.2	2.0
Kennebec				1.3	1.0
Russet Rural	1.5	2.9	2.6	2.2	
Cherokee				3.0	1.7
Chippewa	2.1	3.3	2.9	2.2	

[1]Average of 8 color determinations, 2 each by four observers. Color classes were: 1 very light, 2 light golden, 3 dark, but still marketable, 4 dark and unmarketable, and 5 very dark.
[2]After 3 months storage at 40° and 2 weeks at 75° F.
[3]After 3 months storage at 40° and 4 weeks at 75° F.
[4]Nine weeks at storage 40°, then 14 days at 75-80° F.
[5]Conditioned 25 days at 75-80° F. after 4 months storage at 40° F.

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THE EVALUATION OF POTATO SEEDLING VARIETIES FOR FIELD IMMUNITY FROM POTATO VIRUS A[1]

R. E. WEBB AND E. S. SCHULTZ[2]

Resistance to potato virus A in potato, *Solanum tuberosum* L., is heritable (5, 6). Potato varieties and seedlings inoculated with this virus can be grouped as follows: (a) highly resistant; (b) seldom infected in the field but readily infected by tuber grafting; (c) moderately resistant to infection and manifesting mild mosaic symptoms in the field (Figure 1, B); and (d) as susceptible to infection as the Green Mountain variety and expressing similar symptoms (Figure 1, C). One of the principal objectives in development of seedling varieties with multiple-disease resistance is obtaining those with high resistance to virus A. Such high resistance actually constitutes immunity under field conditions. Field-immune potato seedlings react to inoculation with virus A as follows: (a) by not becoming infected after repeated infestation with viruliferous aphids (*Myzus persicae* (Sulz.)) but by being susceptible to infection by tuber-grafting or inarch-grafting with diseased specimens, and the virus survives in the tubers; and (b) by developing top necrosis (Figure 2) but having no recoverable virus in grafted plants or their tuber progeny (1, 2, 3, 4, 5).

Efficient and effective methods and techniques for evaluating large seedling populations for resistance are requisite for successful development of disease-resistant varieties. Techniques effective for determining field immunity from virus A have not appealed to many investigators because 3 plant generations were required for determination of the reaction of seedling varieties to inoculation. In such tests, 25 to 40 per cent of the plants failed to develop distinctive reactions and had to be retested. In 1955 Webb and Buck (7) found that *Solanum demissum* Lindl. P. I. 175404 gave a distinctive reaction (local lesions, Figure 3) when inoculated with virus A and was, therefore, a good diagnostic host for detecting this virus in susceptible potato seedlings. This host has proved valuable in developing an effective and efficient method of screening potato seedling varieties for field immunity from potato virus A. Its use eliminates the field test and a substantial amount of the greenhouse space previously required for such tests. A preliminary report has been presented (8).

DETERMINATION OF FIELD IMMUNITY FROM VIRUS A IN POTATO

In previous tests, evaluation of potato seedling varieties for field immunity from virus A began in the field. When they were 4 to 6 inches high, plants in each of 3 hills of each seedling variety were inoculated with virus A by means of viruliferous aphids. Since symptoms of virus A infection usually do not show during the year of inoculation, a tuber from each hill was harvested for diagnosis in the greenhouse. Each seedling variety was indexed for susceptibility by the inarch grafting (Figure 4) of a plant grown from each tuber to a healthy plant of Green Mountain.

[1]Accepted for publication January 29, 1959.

[2]Plant Pathologist and Collaborator, respectively, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville Md.

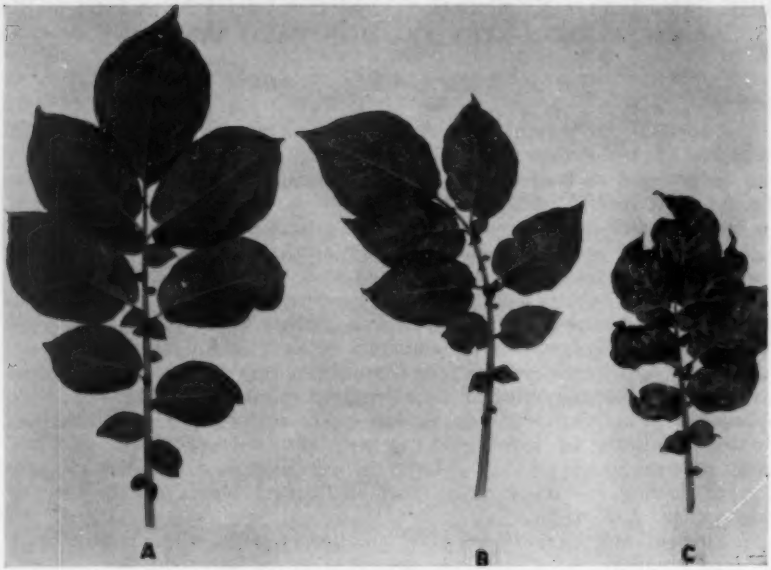

FIGURE 1.—Reaction of potato seedling varieties to inoculation with virus A: (A) symptomless, (B) mild mosaic, and (C) crinkle mosaic.

Mild or crinkle mosaic symptoms developed in plants of Green Mountain grafted with infected plants of the seedling varieties. This procedure eliminated from further tests seedling varieties susceptible to virus A under field conditions. Resistant seedling varieties were replanted and 3 plants of each were inarch-grafted with virus-A-infected plants of U.S.D.A. potato seedling 41956. In 35 to 40 days after grafting, the reaction of plants of each seedling variety was recorded as mottled, field-immune but graft-susceptible, top necrotic (field-immune but the virus not recoverable from plants or tubers), or symptomless (Figure 1, A). The results of one such test are presented in table 1.

Of the 549 seedling varieties inoculated in the field, 85 (15.5 per cent) were susceptible to aphid inoculation with virus A (Table 1). Of the 464 seedling varieties inoculated by inarch grafting with virus-A-infected plants of seedling 41956, 86 (18.5 per cent) showed a foliar mottle, 194 (41.8 per cent) developed top necrosis, and 184 (39.7 per cent) were symptomless. Subinoculation from 100 of the symptomless seedling varieties to *S. demissum* P. I. 175404 showed that 62 seedlings were symptomless carriers of potato virus A. Plants of 34 of the remaining 38 graft-inoculated symptomless seedling varieties were further indexed for susceptibility by grafting to healthy plants of Green Mountain. Symptoms of virus A infection did not develop in the grafted Green Mountain plants, a further indication that these seedling varieties were immune from virus A.

FIGURE 2.—Top necrosis of the type shown by potato seedling varieties hypersensitive (field-immune) to graft inoculation with potato virus A.

The results just presented indicated the necessity of improving the efficiency of virus A detection in the evaluation of potato seedling varieties for field immunity from this virus. Normally, all seedling varieties not developing a distinctive reaction to graft inoculation with virus A would be included in another series of field and greenhouse tests. Since *S. demissum* P. I. 175404 gives a distinctive reaction (Figure 3) in 4 to 6 days after inoculation from virus-A-infected plants, each test series can now be completed with greater efficiency and reliability than was previously possible.

Approximately 12 months was required to conduct the tests necessary to evaluate the seedling varieties shown in table 1. The efficiency of

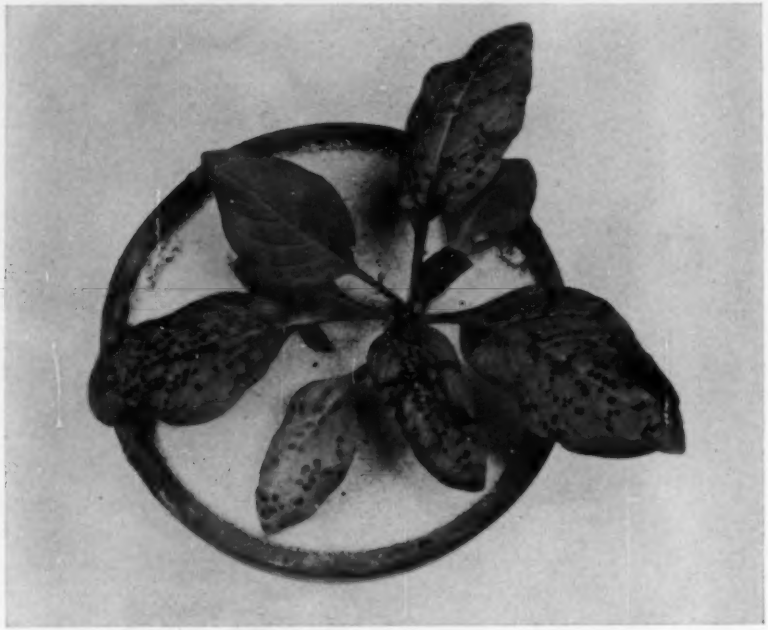

FIGURE 3.—*Solanum demissum* P.I. 175404 showing local lesions 8 days after inoculation with potato virus A.

S. demissum P. I. 175404 as a diagnositc host for potato virus A shortened the test period about 4 months through the elimination of the graft test to Green Mountain for the indexing of the aphid-inoculated seedling varieties. Preliminary tests in the field and greenhouse indicated that the test period could be further shortened by evaluating the seedling varieties for field immunity from aphid inoculation with virus A under greenhouse conditions. This would also eliminate 1 plant generation from the tests. Of 222 seedling varieties that were aphid-inoculated in the field and in the greenhouse 16.4 and 18.4 per cent, respectively, of the plants became infected with the virus.

The data in table 1 indicate that in progenies from parents segregating for field immunity from virus A, more of the seedling varieties are graft-immune than are susceptible to aphid inoculation. Early diagnosis of seedling varieties possessing this type of field immunity would substantially reduce the facilities necessary to determine seedling varieties immune from infection with virus A when inoculation is by aphids. Preliminary tests during the short, cool days of December and early January indicated that the development of top necrosis in graft-immune seedling varieties during this period was similar to that in seedling varieties grafted with virus-A-infected scions during March and early April. Of 278 plants graft-inoculated with virus A in December and early January, 76 per cent

FIGURE 4.—Inarch-graft method used in grafting virus-A-infected plants of potato seedling 41956 to potato seedling varieties.

developed top necrosis. In March and early April, 532 plants were graft-inoculated and 79 per cent of them developed top necrosis. Irish Cobbler, a top necrotic reactor, was used as the control in both tests, and approximately 80 per cent of the graft-inoculated plants developed top necrosis in each test.

Results of these tests indicated that potato seedling varieties could be effectively tested for field immunity from virus A entirely under greenhouse conditions. During the past 3 years, the following procedures under greenhouse conditions have proved efficient and highly effective in the evaluation of seedling varieties for field immunity from virus A and for the type of immunity inherent in each. A large percentage of the seedling varieties selected from parents possessing field immunity from virus A show a top necrotic reaction to this virus when graft-inoculated (Table 1). These are eliminated from further tests by grafting plants of all seedling varieties with virus-A-infected plants of seedling 41956 (Figure 4). About 35 days after grafting, the seedling varieties developing top necrosis are recorded and the plants removed from the test. Subinoculations (Figure 5) from mottled or symptomless plants of all the remaining

TABLE 1.—*Reaction of potato seedling varieties to inoculation with potato virus A.*

Parentage	Seedling Varieties in Test	Aphid-inoculated Seedling Varieties that Become Mottled[1]	Graft Inoculated[2] Seedling Varieties		
			Mottled	With Top Necrosis	Symptom-less
	Number	Number	Number	Number	Number
B 595-76 x Earlaine	46	8	5	25	8
B 606-67 x Earlaine	25	3	0	18	4
Chippewa x Katahdin	24	0	6	0	18
Earlaine x 929-32	42	5	3	28	6
Irish Cobbler x Earlaine	84	17	1	52	14
Irish Cobbler x Cherokee	58	27	1	11	19
Katahdin selfed	86	4	27	0	55
Earlaine selfed	92	10	13	40	29
B 881-12 selfed	32	6	19	0	7
B2429-92 selfed	31	0	3	20	8
Cherokee selfed	29	5	8	0	16
Total	549	85	86	194	184

[1]*Myzus persicae* placed on plants in the field and plants indexed by inarch grafting to healthy Green Mountain plants.

[2]Virus-A-infected plants of potato seedling 41956 were inarch-grafted to plants of seedling varieties. Three hills of Green Mountain planted after each block of 50 seedling varieties, were used as the susceptible control. All plants of Green Mountain became diseased.

seedling varieties are made to plants of the indicator host *S. demissum* P. I. 175404. Diagnosis of suscepibility to graft inoculation with virus A is made in 4 to 6 days and is evident by the development of local lesions on the indicator plants (Figure 3).

Seedling varieties susceptible to virus A by graft inoculation are replanted in 3-hill lots. When the plants are 1 to 2 inches tall, they are infested with 25 to 50 aphids previously fed for about 30 minutes on virus-A-infected leaf tissue. The plants are then enclosed in a ventilated pliofilm cage (Figure 6), and after 24 hours the aphids are killed with an insecticide. After an incubation period of 30 to 35 days, diagnosis of infection is made by subinoculating from each inoculated plant to plants of the indicator host. Seedling varieties not infected by aphid-inoculation in this test are considered field-immune from virus A.

DISCUSSION

The evaluation of potato seedling varieties for immunity from virus A has proved feasible under greenhouse conditions. The technique is highly effective in detecting not only those seedling varieties field-immune from virus A but also the type of immunity inherent in each. Four separate tests are necessary to determine both types of field immunity from virus A in seedling varieties selected from field-immune parents however, each test is economical in both time and greenhouse facilities when compared with other tests of a similar nature. Inoculations with virus-A-infective

FIGURE 5.—Equipment and method used in subinoculating from inoculated plants of the seedling varieties to plants of the indicator host, *S. demissum* P.I. 175404.

aphids under greenhouse conditions can be done more effectively than can inoculations under field conditions. Predators of the vector, always a concern in field inoculations are usually no problem in the greenhouse. The efficiency of the test involving *S. demissum* P. I. 175404 in the detection of virus A infection in susceptible seedling varieties makes it possible to complete the evaluation tests with great accuracy of results during fall and winter.

SUMMARY

Procedures for the efficient and effective evaluation of potato seedling varieties for field immunity from potato virus A in the greenhouse were developed. Plants of seedling varieties selected from parents possessing field immunity are inarch-grafted with virus-A-infected plants of potato seedling 41956 to eliminate from further tests seedling varieties that show top necrosis and are, thus, field-immune from the virus. Subinoculations to plants of *Solanum demissum* P. I. 175404 (local-lesion host) from mottled or symptomless plants about 35 days after grafting will detect, in 4 to 6 days, all seedling varieties susceptible to virus A. These susceptible seedling varieties are replanted, and when the plants are 1 to 2 inches tall they are infested with 25 to 50 virus-A-infective aphids for a 24-hour-period. After an incubation period of 30 to 35 days, diagnosis of infection is made by subinoculation from each plant to the indicator host. Seedling varieties not infected by aphid inoculation are considered field-immune from virus A.

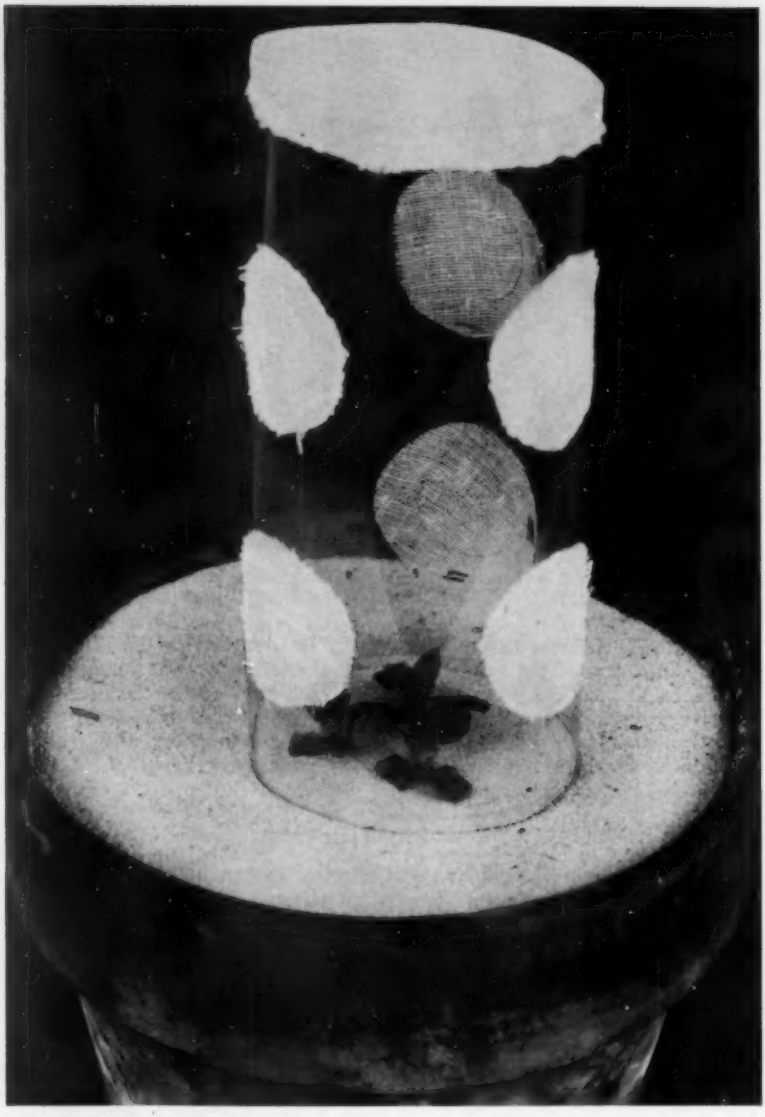

FIGURE 6.—Method of inoculating potato seedling varieties with virus-A-infective aphids in the greenhouse.

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FORECASTING LATE BLIGHT OF POTATOES IN THE HILLS OF WEST BENGAL.[1]

H. C. CHOUDHURI[2] AND S. C. PAL[3]

Late blight of potatoes caused by *Phytophthora infestans* (Mont.) de Bary is a serious disease of potatoes in the hills. It causes a considerable loss of potatoes. Although the late blight appears every year in the hills as has been referred by Choudhuri (2), there is considerable variation on the date of appearance of the disease.

The potato blight spray warning service in other countries has proved very successful since this enabled the farmers to protect their potato crop against late blight by timely preventive spraying.

The purpose of the present study is to find out the possibility of forecasting late blight of potato for the hills of West Bengal so that adequate blight preventive spraying could be applied by farmers.

METHODS

The climatological and blight incidence data were recorded at the Rungbull seed potato farm, Darjeeling (India) which is situated at an altitude of 7,000 feet above mean sea level.

The methods used in the study are those described by Hyre (3, 4). This involved a "moving" graph as developed by Hyre (4). During the whole period of study 7-day total rainfall was compared with 10-day total.

DATA

The climatological data, showing the favorable periods and incidence of late blight for seven consecutive years from 1952 to 1958 are shown in figure 1. It is apparent from the "moving" graph that in six out of seven years late blight forecast by the method described by Hyre (4) would have been accurate.

Figure 2 shows the "moving" graph taking into consideration 7-day total rainfall instead of 10-day total precipitation of the Hyre-method. It is clear from the figure that this 7-day total rainfall gives accurate blight forecast for all the years under study.

The average 10-day total rainfall in Darjeeling is 2.60 inches and the 7-day total rainfall is calculated to be 1.82 inches.

DISCUSSION

Several methods for forecasting late blight of potatoes have been described by Beaumont (1), Wallin *et al.* (6), and Hyre (3, 4). Each method is based on the assumption that the blight pathogen requires, for its rapid development, certain temperature and humidity or temperature and rainfall relationships.

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[1]Accepted for publication December 1, 1958.

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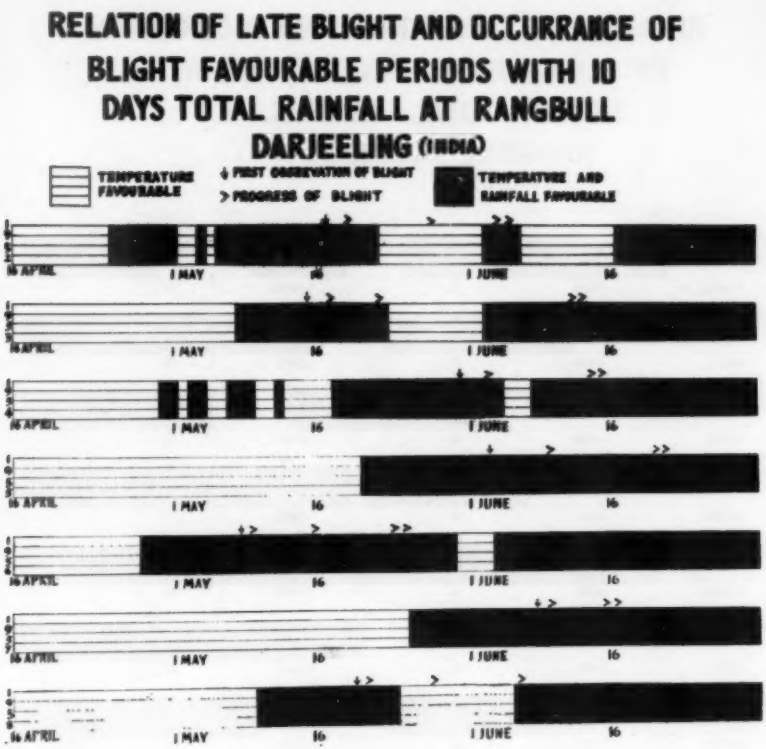

FIGURE 1.—Climatological data showing favorable periods and incidence of late blight with 10-day "moving graph," 1952-1958.

Beaumont (1) has described the "48-hour" method. It involved "Beaumont periods" consisting of 48 hours or more consecutive hours with a temperature of 50° F. or more and a relative humidity of not less than 75 per cent. Late blight is expected to appear within three weeks after the first such "Beaumont period" following a suitable starting date. Wallin and Hoyman (7) discussed a "10-hour" method in which, during a seven-day period, one period of ten or more consecutive hours of 75° F. or less with a relative humidity of 90 per cent or more is suitable for blight development. It has been considered by Wallin and Hoyman (7) that the more frequently such favorable periods occur the greater are the chances for development of blight.

Hyre (4) developed the "moving graph" method based on temperature and rainfall. He considered that predictions based on "moving graph" is more accurate than two other methods. Hyre (4) also found that "10-hour" and "48-hour" methods based on humidity and temperature are of

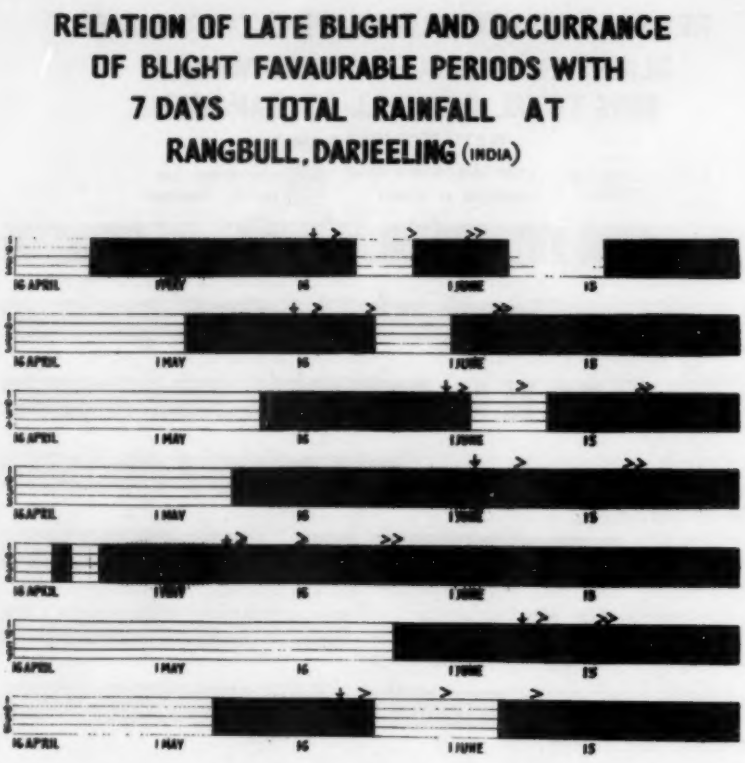

FIGURE 2.—Climatological data showiwng favorable periods and incidence of late blight with 7-day "moving graph," 1952-1958.

questionable value for areas where relative humidity is consecutively high for many hours during the night, a condition prevalent at Rungbull in Darjeeling where the humidity is always above 90 per cent.

It is seen from figures 1 and 2 that the 7-day moving rainfall is more reliable than 10-day moving rainfall in forecasting late blight in the hills of West Bengal.

SUMMARY

Climatological data showing the favorable periods and incidence of late blight for seven consecutive years from 1952 to 1958 were studied by the "moving graph" method of Hyre. The "moving graph," using a 7-day total rainfall instead of a 10-day total, proved to be more accurate in forecasting late blight in the Darjeeling hills of West Bengal.

The average 10-day rainfall in Darjeeling is 2.60 inches and the 7-day total rainfall is calculated to be 1.82 inches.

Acknowledgment

The authors desire to thank Mr. S. Banerjee, Inspecting Officer (Potatoes), for his assistance.

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A VIRUS DISEASE OF TREE TOMATO—*CYPHOMANDRA BETACEA* SENDT.—DUE TO POTATO VIRUS Y.[1]

K. S. Bhargava* and R. D. Joshi[2]

During the winter of 1957-58 a hitherto unreported disease of tree tomato was observed in a private garden in Bhimtal. Since then the disease has been noticed in various other areas in the vicinity of Naini Tal. More than 50 per cent of the plants inspected showed severe infection. The affected plants show no loss in vigor, but the younger leaves show pronounced mosaic mottling symptoms with light and dark green areas along the veins. It was suspected that the causal agent was a virus.

Fukushi (3) reported a virus disease of tree tomato from Japan ,and Chamberlain (1) listed tree tomato plants as having a mosaic in New Zealand. Chamberlain (2) further reported that tree tomato plants were found infected with cucumber mosaic virus, potato virus Y and also with a mixture of the two viruses. Preliminary experiments indicated that the present disease of tree tomato was due to a strain of potato virus Y.

The purpose of this paper is to record detailed observations on the disease as found in this region of India.

Symptoms of the Disease on Tree Tomato

Symptoms on the leaves are the most prominent, but there is no reduction in the shape and size. However, the younger leaves show light and dark green mottling, in which there are dark green areas along the veins. This tends to spread causing a distinct mottle along the entire surface of the leaves (Figure 1, A & B). The symptoms become less pronounced when the temperature is high during April to July. The fruits develop dark blemishes which are of irregular shape. The yield is also much reduced.

Sap Transmission and Host Range

The virus is sap transmissible, but transmission is accelerated by using carborundum as an abrasive on the leaves to be inoculated. The following plants were sap inoculated and their reaction is as follows:

Nicotiana tabacum L., var. White Burley. First symptoms appear as clearing of the veins in about six days (Figure 1, C). Later this vein clearing becomes less prominent and diffused, and is followed by a mosaic mottling.

Nicotiana glutinosa L. leaves show clearing of veins ten days after inoculation which later tends to disappear and is followed by mild mosaic. The plant is much stunted and the leaves are reduced in size. Sometimes the sepals become leafy and more elongated.

Nicotiana rustica L. and *Datura metel* L. leaves show a pronounced vein-clearing.

Datura stramonium L. did not show symptoms nor could the virus be recovered from the inoculated plants. This plant is immune to the virus.

[1]Accepted for publication December 8, 1958.

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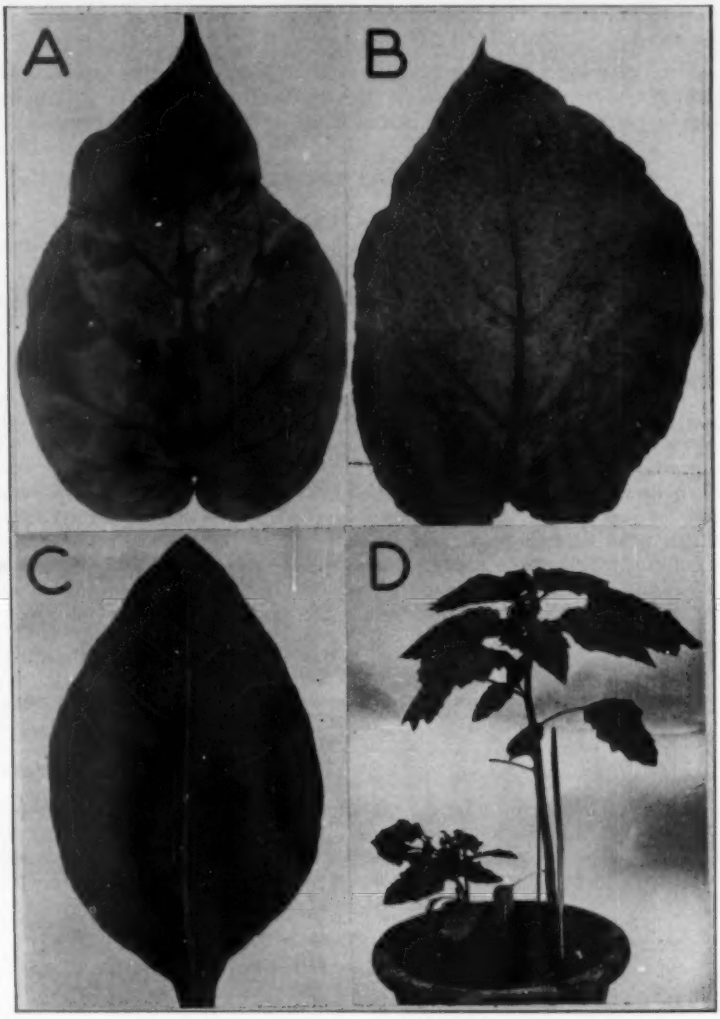

FIGURE 1.—A and B, Infected leaves on tree tomato showing mottle; C, infected leaf of White Burley tobacco variety showing clearing of the veins; and D, two plants of *Nicandra physaloides*. Infected plant is much dwarfed.

Nicandra physaloides Gaertn. leaves show vein-clearing followed by mild mottling. The entire plant shows stunting, but no necrosis was visible (Figure 1, D).

Lycopersicum esculentum Mill. Tomato. Infected plants show mild mottling of the leaves.

The following plants were also inoculated with infective sap but they did not show any symptoms and remained healthy: *Cucumis sativus* L.,; *Phaseolus vulgaris* L.; *Vigna sinensis* Endl. and *Capsicum annuum L.*

Physical Properties

Dilution end point: Infective sap from diseased tobacco plants was diluted to different strengths with distilled water, and six tobacco plants, var. White Burley, were inoculated with each dilution. Undiluted sap served as a control. The results are given in table 1.

Table 1.—*Dilution end point.*

	Dilution				
Plants (No. infected of 6 inoculated)	Control	1.10	1:100	1:1,000	1:10,000
	5	3	2	0	0

Thermal inactivation point: Infective sap (2 ml.) from diseased plants of tobacco, var. White Burley, was taken in each of 8 thin-walled tubes. One tube was kept at room temperature and the others were maintained at a definite temperature for ten minutes in a water bath. After treatment the sap was cooled rapidly and rubbed on the leaves of healthy tobacco plants, var. White Burley. The results are given in table 2.

Table 2.—*Thermal inactivation point.*

	Temperature (°C)						
Plants (No. infected of 6 inoculated)	Control	40	45	50	55	60	65
	5	3	3	2	0	0	0

Resistance to ageing: Four 5 ml. aliquots of infective sap from tobacco plants, var. White Burley, were kept at room temperature for varying periods, before being inoculated to batches of six tobacco plants. The results are tabulated in table 3. Fresh expressed infective sap served as a control.

Table 3.—*Resistance to ageing.*

	Length of period				
Plants (No. infected of 6 inoculated)	0 hr.	24 hrs.	48 hrs.	72 hrs.	96 hrs.
	6	2	0	0	0

Aphid Transmission

Of the three species of aphids worked with, *viz.*, *Myzus persicae* Sulz., *Macrosiphum pisi* Kalt. and *Brevicoryne brassicae* L. only *M. persicae* transmitted the virus from diseased to healthy tobacco plants. The virus proved to be of the non-persistent type.

Serology

The infective sap showed positive reaction with the antiserum against potato virus Y and negative reactions with the antiserum against potato virus X, and the cucumber mosaic virus. The virus Y antisera were obtained through the courtesy of Prof. E. van Slogteren of Wageningen, Holland.

Discussion

Chamberlain (2) in New Zealand reported that the plants of *Cyphomandra betacea* were found infected with cucumber mosaic virus, potato virus Y and also with a mixture of the two viruses. The results of the present investigation show that the host range of the virus causing a mosaic of tree tomato resembles potato virus Y. It also resembles potato virus Y in its physical properties, *viz.*, dilution end point, thermal inactivation point and resistance to ageing. Results of serological tests prove conclusively that the tree tomato virus is a strain of potato virus Y.

Tree tomato plants are perennial, and are grown in small numbers in nearly all the allotments in this region. Plants are known to harbor *Myzus persicae* and other insects during the winter months. Since potato is a principal crop of this region, it is very likely that diseased tree tomato plants act as a potential source of infection to the potato crop. Presence of *Myzus persicae* on tree tomato indicates that these aphids might be acting as active vectors for the spread of virus Y to the potato crop.

Summary

A virus disease of tree tomato due to a strain of potato virus Y is described. The results are based on host range, physical properties and serology. It is suggested that tree tomato may be one of the harboring hosts of potato virus Y found prevalent in the potato crop.

Acknowledgments

This investigation was carried out under a scheme financed by the U.P. Scientific Research Committee, to whom grateful thanks are expressed for financial assistance.

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NEWS AND REVIEWS

ABSTRACTS OF PAPERS PRESENTED AT THE FORTY-THIRD ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

UNIVERSITY OF NEW BRUNSWICK FREDERICTON, NEW BRUNSWICK, CANADA

AUGUST 12, 13, 14, 15, 16, 1959

BAGNALL, R. H. AND D. A. YOUNG

INHERITANCE OF IMMUNITY TO VIRUS S IN THE POTATO

The virus-X-immune potato variety Saco is also highly resistant or immune to potato virus S. We have tested for S-immunity, seedlings from a number of crosses of which Saco was one parent, and also from selfed Saco. Where Saco was crossed with an unrelated seedling, susceptible to both viruses S and X, we found no immunity to virus S. Where Saco was crossed with a seedling that, like Saco, was an X-immune offspring of Seedling 41956, a small percentage of S-immune seedlings resulted. The percentage of S-immune progeny of Saco, selfed, was substantially higher. Although the immunity to viruses S and X appears to be derived, in part at least, from Seedling 41956, there does not seem to be any correlation between immunity to virus S and immunity to virus X in the seedlings we have tested.

BIENZ, DARREL R.

A COMPARISON OF POLLEN BEHAVIOR AND POLLEN-TUBE GROWTH IN STYLES OF POTATO FLOWERS GROWN ON CUTTINGS WITH THOSE OF FLOWERS REMAINING ON THE PLANT

Certain crosses using pollen from male-fertile potato clones on stigmas of clones which are female-fertile consistently failed to produce fruit. These "incompatible" crosses set fruit much more readily if the stem bearing flower buds of the female is cut from the mother-plant and placed in a mineral nutrient solution before the flower buds open. Histological examination of styles from these "incompatible" crosses shows that more pollen grains remain on the stigma, that a higher percentage of these germinate, and that the progress through the style of those which germinate is much more rapid when the pollinated flowers are growing on cuttings in nutrient solution than when they remain on the plant.

BRILL, G. D., J. C. CAMPBELL, AND G. R. BLAKE

IRRIGATION AND SOIL MANAGEMENT STUDIES WITH POTATOES IN NEW JERSEY

Over a period of 10 years, the effect of irrigation and crop rotation on potato yields and quality was studied.

The application of 1 inch of water per week through portable rotating sprinklers when rainfall was deficient resulted in an average yield increase of 36 per cent or 85 bushels per acre. Average yield increase in the dry years, 1949 and 1953-55 was 148 bushels per acre. A two year crop rotation of potatoes and wheat and a three year rotation of potatoes, wheat and hay produced significantly larger yields than did continuous potato culture.

Yield increases due to irrigation were greater with rotations than with continuous cultivation, however, yields were similar in the 2 and 3 year rotation with irrigation. Without irrigation, potato yields were highest in the 3 year rotation.

Potatoes were fertilized with 1 ton of 5-10-10 per acre, the wheat with 300 pounds of 5-10-10 and the hay with 500 pounds of 0-14-14 per acre.

Soil aggregate stability was significantly greater in the 2 rotation treatments than in the continuous plots. Lowest aggregate stability was found in the wheel rows of the continuous plots.

The specific gravity of potatoes grown in the 2 and 3 year rotations was appreciably higher than in the continuous plots after 6 years of continuous cultivation.

CARPENTER, PAUL N.

MINERAL NUTRITION OF POTATOES

The need for information on the nutrient content of potato plants at various stages of growth and with various soil treatments caused the initiation of this study in 1953.

Potato top, tuber and seed piece samples have been taken from replicated plots differentially fertilized, and analyzed for the major mineral nutrients during each of the growing seasons since 1953. These data show the needs of the potato plant in terms of percent composition, needs per plant and comparative amounts of each element at various stages of growth.

ESTES, GEORGE O. AND HAROLD W. GAUSMAN

SOME EFFECTS OF VARIOUS SULFUR TO MAGNESIUM RATIOS

A factorial design in a randomized complete block with five replications was used to study the effects of various S:Mg ratios on potato growth, quality, and nutrient relationships. Treatments consisted of S and Mg, each at 0, 10, 20, and 30 lbs. per acre. Virgin Caribou loam was used with N, P_2O_5, K_2O, and $Ca(OH)_2$ applied at 120, 240, 240, and 1,000 lbs. per acre, respectively. Ratios had no statistically significant effect on soluble salt concentrations or pH of the soil.

Results are based primarily on the first crop, although a cursory examination indicates that subsequent cropping has tended to accentuate the effects of S:Mg ratios on potato growth.

High levels of Mg depressed total plant yield; while variations in S had little influence. The combined data of two crops indicate that Mg at 30 lbs. per acre in combination with 10 lbs. S resulted in the greatest dry weight of tops. The average tuber yield of the first two crops was greatest with 10 lbs. Mg:20 lbs. S and 30 lbs. S:30 lbs. Mg.

Plant height was increased by additions of S, but it was decreased by Mg. No statistically significant effects of Mg and S were observed on specific gravity of tubers.

A pronounced Mg:N interaction was present. As Mg was increased, the N and Mg content of tops increased, with little effect on the tubers and roots. Mg tended to delay maturity (blossoming).

Mg additions resulted in increased S uptake in the tops with no noticeable effect on roots and tubers. P, Cl, Ca, and K were not noticeably affected by S:Mg levels.

S:Mg ratios affected the distribution of S^{35} in leaflets of the plants. The 0 S:30 Mg ratio caused S^{35} to concentrate near the edges of the leaflet while 30 S:O Mg and 30 S:30 Mg ratios gave a unform distribution of S^{35} in the leaflets.

GAUSMAN, HAROLD W.

SOME EFFECTS OF CHLORIDE IN THE NUTRITION OF THE POTATO PLANT

Cl^- deficiency symptoms occurred on potato plants containing 0.0143 to 0.0381 me. of Cl^- per gram of plant material on a dry weight basis. Potato varieties responded differently to levels of Cl^-, Russet Rural being extremely sensitive to low levels of Cl^-.

Cl^- and $SO_4^=$ had a differential effect on the uptake of P^{32}. As Cl^- was increased in the substratum, P^{32} uptake increased until an apparently critical concentration of 300 to 450 ppm. of Cl^- was reached. As $SO_4^=$ was increased in the substratum, P^{32} uptake tended to decrease.

A highly significant correlation of —0.754 was found between Cl^- and $SO_4^=$ content in the entire potato plant. Results further indicated that Cl^- levels had little influence on the $SO_4^=$ content of roots but was most evident in the $SO_4^=$ content of tops and tubers.

Quantitative chemical analyses for total P^{31} on potato tissue lyophilized at harvest time presented a different picture than the results with P^{32} which were obtained at the approximate time of flowering. The greatest P^{31} uptake occurred with the low and high Cl^- treatment (0 and 600 ppm., respectively); while the intermediate Cl^- treatments, (200 and 400 ppm.) resulted in the lowest P^{31} uptake. Dry matter content was not necessarily associated with the total P^{31} content.

Evidence has been obtained which indicates that chloride affects the phosphate

esters. As an example, tubers grown in nutrient solutions with 0 Cl^- had a higher content of Fructose-1-6-diphosphate than tubers grown in nutrient solutions containing 600 ppm. Cl^-.

HAWKINS, ARTHUR

PLACEMENT AND SOURCE OF POTASH ON YIELD AND SOLIDS CONTENT OF POTATOES

Under exceptionally dry conditions of 1957, reducing the amount of nitrogen and potash applied in side bands at planting time by broadcasting part of it before planting or sidedressing part of the nitrogen and potash resulted in better growth and significant yield increases over applying all in the row side bands at planting time.

At two locations in 1958, with the early part of the season having favorable soil moisture and temperature conditions, sidedressing either one-half or all the potash resulted in as good or slightly better yields as compared with the standard method of applying all the fertilizer in the row at the time of planting. Sidedressing one-half or all the potash resulted in tubers of higher dry matter, whether the source of potash was chloride or sulfate. The sulfate source resulted in tubers of higher dry matter with all placements.

Possible advantages of sidedressing a part or all of the potash as well as a part of the nitrogen for potatoes is discussed, including better stands of potatoes, especially in dry seasons; reducing loss of nutrients by leaching during wet seasons, and possible reductions in cost as compared with applying all the fertilizer in the standard side band placement.

HAWKINS, ARTHUR

POTATO PLANTER ATTACHMENT FOR DISPENSING WEIGHED QUANTITIES OF FERTILIZER OR CHEMICALS FOR POTATO PLOTS

The principle of the fertilizer dispensing attachment is to discharge fertilizer from an endless belt (4 feet long), maintained in a horizontal position. A weighed quantity of fertilizer or chemicals is placed in the channel on the belt from point of discharge to a calibrated point on the belt provided with a block or riser.

Dr. S. M. Raleigh, now at Pennsylvania State University, built the first fertilizer attachment for potatoes in Maine for use by the author in 1939. This machine has since been modified, using interchangeable sprockets to vary speed of belt for short plots and plots up to 120 feet.

The most recent improvement in the machine in Connecticut is the use of a quickly adjustable leveling device for leveling fertilizer to uniform depth on the belt. This better insures that each foot of row more nearly receives about the same amount of fertilizer or chemicals.

The use of this machine permits precision placement of fertilizer in short plots in Super Magic Latin Squares or other field plot designs.

HANSEN, HENNING P.

TOBACCO MOSAIC VIRUS CARRIED IN POTATO TUBERS.

A collection of "wild" potato species from South America included a clone (no. 67a, coll. Petersen & Hjerting) stated to be *Solanum commersonii* Dun. subsp. malmeanum (Bitt.) Hawkes (=*S. millanii* Buk. & Lechn.).

All plants of this clone 67a showed a stunted appearance with somewhat rigid leaves and diffuse yellowing. They were found to contain a virus which was regularly carried in the tubers of the clone.

The virus in question was found to be a strain of the tobacco mosaic virus with which it is serologically related; it also possesses similar physical properties, and in *Nicotiana glutinosa* L. it produces similar local lesions. In *N. tabacum* L. var. Samsun the symptoms may vary, but there is a special tendency to ringlike mosaic or necrotic rings and line patterns, unusual for tobacco mosaic. Sometimes internal stem-necrosis was observed, reminding of Rotterdam-B disease, but virus 67a was not found to be soil-borne as the latter. Sap inoculations to leaves of some commercial potato varieties resulted in local lesions, sometimes followed by more or less systemic mosaic and necrotic lesions.

HANSEN, HENNING P.

SIMPLE DESIGNATIONS OF POTATO-INFECTING VIRUSES IN ACCORDANCE WITH THE PERIODICAL SYSTEM OF PLANT AND ANIMAL VIRUS INTERRELATIONSHIPS

Natural interrelationships between viruses depend on their biochemical properties, because:

A virus is a substance — or a combination of substances — with ability to reproduce itself synthetically as an integrating, but irregular component of living organisms.

Virus species and strains are distinguished by serological and similarly specific biochemical properites. Further biochemical properties, which characterize larger virus groups, cause specificity as regards particular functions and associated tissue-types, which again form the immediate background of the ways of infection and of symptoms induced by the virus in its host. Through these effects the biochemical properties indirectly determine the general behavior of the individual virus disease: Epidemiology, geographical distribution, detrimental effects, and control-possibilities.

The author has shown that plant — and vertebrate — infecting viruses form parallel series of natural groups corresponding to parallel, periodical-biochemical systems of the organisms involved. For viruses in general a simple nomenclature was proposed, namely formulas composed of direct or indirect symbols of the periodical system concept of the host category in question — as an empirical indicator of biochemical properties — supplemented by symbols of particle-types.

In plant viruses it is justifiable to represent the biochemical main criteria by equivalent symbols for direct transmission and vector-relations. The resulting name-formulas are by themselves objective, *i.e.* they describe the actual combination of the ways of infection, and the actual particle-type (if known) of the virus in question. However, indirectly they suggest the general behavior and other correlated properties of the virus.

A simple key to such name-formulas will be presented. Furthermore it will be demonstrated by potato-infecting viruses that the formulatory designation is an easy and practical tool for identification of viruses, and that it tends to support comparisons between more or less similar viruses, occurring in different hosts and in different countries.

HOOKER, W. J., W. S. KIM, AND N. R. THOMPSON

DISTRIBUTION OF POTATO VIRUS X IN TOLERANT POTATOES

Concentration of potato virus X (PVX) in potato plants of tolerant varieties was determined by micro-serological precipitin tests and by local lesion assay on *Gomphrena globosa*.

Results obtained by the two methods were generally in good agreement except in analysis of tubers and upper stems. Concentration of PVX was highest in upper and middle leaves and somewhat lower in the lower leaves. Relatively low concentrations were obtained in the stem with lowest concentrations in the lower stems. Concentration of PVX in roots was slightly higher than in stems. In the tubers, PVX was almost as concentrated as in the leaves when measured by local lesion assay, but activity was low when the two methods of assay were in the upper stems which had considerable amounts of PVX as measured by local lesion assay and a low virus titre in the serological test.

PVX concentrations in 42 naturally infected certified seed lots which included 13 varieties was determined twice during the season. Except when a seed lot remained free of the virus, the concentration of PVX was essentially similar between varieties and between different seed lots of the same variety.

HOOKER, W. J. AND W. S. KIM

INHIBITORS OF POTATO VIRUS X IN LEAVES OF POTATOES WITH DIFFERENT TYPES OF RESISTANCE TO THE VIRUS

Inhibitors of potato virus X (PVX) in leaves of potato varieties tolerant, hypersensitive, and immune to virus X were demonstrated by local lesion infection of *Gomphrena globosa*. When leaf juice was spread on the upper surface of *G. globosa* leaves before inoculation with PVX, infection was reduced to approximately 35 per cent of the control. There were no statistically significant differences between leaf juice of the varieties tested. Infection was unimpaired when leaves were first inoculated and leaf juice placed on the surface for as short time as 1 minute after inoculation.

When the virus was mixed with leaf juice, infectivity of the mixture was reduced during an 8-day period of observation. There were no differences in the extent of inhibition between varieties.

Inhibitors were most concentrated in crude juice and in the supernatant following centrifugation at 7000 g. for 15 minutes. They were almost absent in the final precipitate following centrifugation, heating at 55° C. for 10 minutes, and a second centrifugation. The unheated precipitate and the heated supernatant were intermediate in inhibitory activity.

Tolerant, hypersensitive, and immune varieties were equally inhibitory to PVX and it is postulated that the inhibitor affects the virus more directly than it does the host test plant.

HOUGAS, R. W. AND S. J. PELOQUIN

HYBRIDS OF *SOLANUM TUBEROSUM* HAPLOIDS AND THE TUBER-BEARING *SOLANUM* SPECIES

Hybrids have been obtained following matings of *S. tuberosum* haploids ($2n = 24$) with 23 tuber-bearing *Solanum* species ($2n = 24$) involving the taxonomic series Tuberosa, Demissa, Commersoniana, Cuneolata, and Megistacroloba. The total number of seeds obtained from such matings is upward of 105,000. Small populations (25 - 50) of F_1 hybrids have been grown from 161 of these combinations. The majority of the F_1 plants are vigorous. F_2 and BC_1 populations of 5 combinations have been grown. Such matings present a new method of exploring the germ plasm of the diploid *Solanum* species as well as for gene transfer from these species to the common potato.

Matings between 5 *S. tuberosum* varieties (Cherokee, Early Gem, Katahdin, Kennebec, and Merrimack) and *S. tuberosum* haploids have been made. Seed set following such matings is very low in the limited trials to date. The triploid and tetraploid F_1 hybrids from these matings are vigorous plants.

HOOVER, EDWARD F. AND PAUL A. XANDER

ANALYTICAL METHODS FOR POTATO TUBER COMPOSITION

A series of relatively simple methods have been combined into fractionation technique for the study of potato composition. By this technique, samples of potatoes ranging in size from single tubers to composite groupings of large lots may be analysed qualitatively, and semi-quantitatively for free amino acids, solube and insoluble proteins, proteins forming complexes with detergents, certain enzyme systems, total reducing sugars, soluble carbohydrates, free sugars, ascorbic acid, aromatic and aliphatic organic acids, sugar phosphates, and mineral constituents.

Data are presented representing analyses of 74 separate lots of potatoes obtained during the 1958 growing season. Varieties included Sebago, Red Pontiac, Delus, Katahdin, Chippewa, Cobbler, Onaway, Kennebec, Rural Russet, and several unnamed seedlings. The potatoes were obtained from six major growing areas in eastern United States from Florida to New York.

The results revealed considerable variation in the qualitative and quantitative aspects of most of the major compositional fractions, particularly when comparisons were made between varieties. Less significant variation was observed between like samples analyzed immediately after harvest than after storage. However, for the most part, the variations observed were not consistent, either as a function of variety or storage or when compared with other properties of the source potatoes such as chipping quality. One significant exception to this was found in the reducing sugars. Here, direct correlation was consistently observed between the occurrence and abundance of glucose and fructose and the tendency of potato chips produced from the tubers to brown during processing.

KEHR, A. E. AND J. C. HORTON

RESISTANCE TO INFECTION BY MECHANICAL INOCULATION WITH VIRUS X IN POTATO

Progeny in the cross of susceptible X 927-3 (female) by susceptible B 2903-17 (male) were found to possess resistance to infection by virus X mechanically inoculated into Irish potato. Preliminary evidence indicated a close similarity to or identity with the immunity from virus X demonstrated by S 41956. Examination of the pedigrees of parental lines and the pedigree of S 41956 showed several similarities, but no common source of resistance was involved. Previously proposed theories of the origin

of immunity from virus X were discussed, and the authors suggested their data support the complementary gene theory of F. J. Stevenson, E. S. Schultz, and C. F. Clark. This is the first report of virus X resistance found as the result of crossing two virus-X-susceptible parental clones.

KIM, W. S. AND W. J. HOOKER

PURIFICATION AND PHYSICAL CHEMICAL STUDIES OF POTATO VIRUS X

A reproducible method of purification of potato virus X (PVX) has been developed using electrochemical properties of virus and host proteins. Purified virus was obtained from infected leaves of tobacco, tomato, *Nicotiana glutinosa* and *Datura tatula*. Modal length of the virus particles as measured with electron micrographs was between 400-500 mu. Purified virus was 100 times more infective than virus-infected tobacco leaves from which the virus had been isolated. The purified virus, homogeneous as a single peak pattern, was obtained electrophoretically when the virus was suspended in 0.1 M borate buffer within the pH range from 3.0 to 10.0. Electrophoretic mobility of the virus protein measured in 0.1 M pH 7.0 borate buffer was 1.22×10^{-5} cm/sec/volt/cm and the isoelectric point was pH 4.4. The sedimentation constant calculated at 20° C. was 206 S and the diffusion coefficient determined to be 1.3×10^{-7} cm^2/sec. The virus was apparently highly hydrated with a specific volume of 0.890 cm^3/gm and a density of 1.123 gm/cm^3. The molecular weight of the virus protein was calculated to be approximately 38.5×10^6 gm/mole.

KIM, W. S. AND W. J. HOOKER

STUDIES ON DEGRADATION PRODUCTS OF PURIFIED POTATO VIRUS X.

Potato virus X (PVX) particles were studied by ultra microscopic examination of degradation products of the virus using various means. Pepsin rapidly digested the outer protein portion of the virus particles whereas trypsin caused aggregation of the particles. Both enzymes reduced infectivity of the virus at pH 7.0, pepsin reduced infectivity slowly, whereas the action of trypsin was immediate. Antigenicity of the virus was decreased with both enzymes. The effect of enzyme treatment was apparently immediate. Ribonuclease inhibited infectivity of the virus. When the virus was dialyzed against pH 2.0 glycine-HCl buffer or against pH 10.7 carbonate-bicarbonate buffer for 48 hours the virus degraded into 2 main components, nucleic acid and protein which have been isolated and characterized. Two drops of 40 per cent formalin in 20 ml. of 0.9 per cent virus suspension reduced infectivity almost to 0. Infectivity was greatly restored by treating the same virus solution in carbonate-bicarbonate buffer (pH 10.7) for 48 hours. Repeated filtration of the virus solution through 2 layers of Whatman No. 1 filter paper under suction in a Buchner funnel broke virus particles into smaller pieces and reduced infectivity to 70 per cent and antigenicity to 50 per cent. When the virus suspension was treated with 10 KC ultrasonic waves for 15 minutes the virus lost infectivity completely with marked reduction of antigenicity. Numerous short fragments of the virus particles were observed under the electron microscope. Virus aggregated and denatured rapidly in water solution, but slowly in pH 7.0 borate buffer.

KLINKOWSKI, M.

A NECROTIC TYPE OF POTATO VIRUS Y

Since 1952 we have studied, in cooperation with K. Schmelzer, a necrotic strain of potato virus Y occurring in Central Germany. It has been called "Tabakrippenbräune-Virus" (Marmor upsilon var. constaenecans). This virus causes varying and often masked symptoms in potatoes which are difficult to differentiate from symptoms caused by other viruses. In July and August all tested varieties show sporadic streak necroses near the veins at the lower side of the leaf — the so-called "late streaks" (Spätstrichel). Variations in the shape of the streaks have been observed. In virus-infected potato plants the stems tilt outward. The proportion of the necrosis in relation to the older known strains of virus Y was: 1954 — 1 : 100; 1955 — 1 : 6.2; 1956 — 1 : 0.8; and 1957 — 1 : 1.

The new strains of virus Y are serologically demonstrable with the same degree of exactness as are strains of potato virus X. Expanded leaves near the tip of the plant are most suitable for the serological test. Positive serological tests for the presence of the virus can be made using field plants produced from diseased tubers

five weeks after planting, when the plants are 3 - 4 inches high. During spring indexing with greenhouse grown plants serological tests can be made as early as the fourth week. When potatoes and tobacco are cultivated close to each other, the grade of infection which the highly susceptible tobacco plants show, makes it possible to forecast the degree of infection of the potatoes.

The new Y-strains depress potato yields in latent infections on the average of 13.8 per cent, in manifest infections of 20.6 per cent. The yield depressions are markedly lower than those caused by the older known strains of virus Y which lower potato yields to about 50 per cent. The influence of the new Y virus strains on maturity is not significant. The progeny of early harvested infected plants show weaker symptoms. This might be caused by lower concentrations of the virus. Since this effect is about four times stronger with the old strains of virus Y, we suppose that the new strains move faster in the plant.

KOZLOWSKA, ANIELA

RELATION BETWEEN ABSORPTION OF POTASSIUM AND PHOSPHATES BY POTATOES AND THE DEVELOPMENT OF VIRUS DISEASES IN THEIR TISSUES

Potatoes growing under the same climatic and soil conditions, show in the case of virus Y infection, a higher per cent of K and P in comparison with healthy plants. Shoots from virus Y infected and healthy potato tubers held in acid and alkaline solutions containing 0.05 M KH_2PO_4, particularly from weak alkaline solutions, showed a stronger absorption of K and P than shoots from healthy tubers.

The potato varieties Akersegen and Voran, free from visible virus symptoms, from the Pomerania district which has optimal conditions for potato cultivation, were transferred to more or less continental conditions; namely, to the area of Cracow in southern Poland and to Hungary. After a year of cultivation, potatoes from 6 places in the south of Poland and 8 places in Hungary showing no virus symptoms, contained about the same amount of K and P as the tubers taken from Pomerania. In the following year potatoes were transferred from Hungary to the neighborhood of Cracow. During the period of vegetation potatoes from the Hungarian "pusta" showed streak symptoms in 100 per cent of plants. Those which came from Soprohorpacz, (an area lying under the influence of the Alps), were infected by virus Y to the extent of 50 per cent.

Tubers from healthy plants on the basis of dry mass contained K_2O up to 2.9 per cent and P_2O_5 up to 0.827 per cent. Tubers from infected plants contained from 3.1 up to 3.76 per cent K_2O and up to 0.93 per cent P_2O_5.

Potatoes transferred from Pomerania to Cracow, in comparison to potatoes which were growing one year in Hungary, contained a low per cent and the level of K and P in the tubers was more or less identical with those from Pomerania. Only in the third year of cultivation were the number of infected plants augmented. The level of potassium in the infected tubers attained 3 per cent.

Pomeranian potatoes transferred to mountainous conditions (Carpathian and High Tatra districts, noted for their lack of aphids and virus infections and soils rich in loam substances) gathered K and P in a considerable per cent. At the same time those plants were highly degenerated and gave a lower yield. Those potatoes when transferred to the lowland showed a better growth, a highr yield, and a lower amount of K_2O and P_2O_5 in the tubers.

Potatoes infected with virus diseases in the mountains, after transplanting into the lowland, showed in the first year more gentle virus disease symptoms, an increase in yield, together with a lowering of K and P in the tubers.

A relationship between the intensity of respiration, the amount of organic acids, amino acids, K and P, and the development of virus protein in the tissues was stated.

KOZLOWSKA, ANIELA

DETECTION OF LATENT STRAINS OF POTATO VIRUS X BY ULTRAVIOLET LIGHT

Tubers of the potato varieties Majestic and Dunber Rover, containing the mild strain of virus X, namely X^H were obtained from the Scottish Plant Breeding Station, Pentlandfield, Roslin. Tobacco seedlings inoculated with the sap from shoots of those potatoes showed no virus symptoms, but the same leaves investigated under U. V. light showed a fluorescence of the veins on the lower side of the leaves. Leaves

which showed the phenomenon of fluorescence under U. V. light gave a positive precipitation test with the antivirus X serum. Because fluorescence under U. V. light sometimes can be caused by other factors the tobacco seedling culture was kept under the best aseptic conditions possible.

The detecton of mild strains of virus X in potatoes from year to year under field conditions, enables one to state that in some cases there is evidence of the receding of mild strains and the appearance of virulent strains of virus X in potato tissues.

The observations under U. V. light of tobacco leaves inoculated with virulent virus strains enables a precise counting of local lesions, and in consequence state more minutely the intensity of the infection.

LARSON, R. H. AND N. OSHIMA

POTATO VIRUS S RECOVERED FROM THE ROOTS OF THE "IMMUNE" VARIETY SACO

After attaining a height of 7 inches single stem plants of the potato variety Saco, grown at 18 to 20° C. from tubers known to be free of viruses F, X, Y, Leafrolling mosaic (M) and the Leafroll virus, were top grafted with virus S infected scions of the USDA potato seedling No. 41956. In each case the inch long graft union was bound with self-sticking elastic latex bandage, and the entire scion and union enclosed in a moistened 2x4x6 inch polyethylene bag which was removed after 10 days. Recovery of virus S was attempted after 6 weeks from the (1) 41956 virus S infected top scion, (2) leaves of the Saco stock, and (3) from roots of the Saco stock; also from the (1) roots and (2) leaves of healthy Saco and 41956 control plants.

Before virus recovery inoculations, the top grafted plants were removed from the soil and the scion, stock and roots thoroughly washed in running tap water. In addition to the top grafted Saco, entire plants of non-grafted Saco and Virus S infected 41956 were also included in the recovery inoculation series as controls. Young plants of *Nicotiana debneyi* were used as recovery test hosts since this plant is known to show very pronounced systemic veinclearing and incipient mottle symptoms in from 21 to 28 days at about 20° C. In order that all virus recovery inoculations from root tissue remain free of the soil-borne tobacco necrosis virus, all plants were grown in steamed-sterilized soil.

In the plants serving as controls, virus S was recovered on *N. debneyi* from both leaves and roots of virus S infected 41956 but not from either the leaf or root tissue of Saco.

In Saco plants, top grafted with virus S infected scions of 41956, the virus was recovered on *N. debneyi* from the scions in all instances, but was not recovered in any case from the Saco stock tissue.

Virus S was recovered on *N. debneyi* in all recovery attempts from roots of Saco plants top grafted with scions of virus S infected 41956. These preliminary studies indicate that, on top graft inoculation, virus S passes through the stem tissues and may multiply in roots of the otherwise immune potato variety Saco.

LIHNELL, D.

STUDIES ON THE ETIOLOGY OF SPRAING

"Spraing" is the English name of a potato disease characterized by rust-colored internal necrosis appearing in the tubers and probably closely related to the American tuber disease "corky ringspot." It is soil-borne, and restricted mostly to light, sandy soils or peat soils, and encountered in most European countries. The cause of the disease has long been obscure, but today there is much evidence in favor of its virus origin.

At the Swedish State Plant Protection Institute studies on the etiology of spraing have been underway for several years. Transmission of the disease to the next tuber-generation has been demonstrated in many experiments. The number of second-generation symptom-bearing tubers is mostly low, but in several cases the disease could be followed through to three or more tuber-generations.

The symptoms in the second and following tuber-generations are of the same type as those in the primarily diseased tubers, but differ somewhat as to pattern and localization in the tuber. The difference can be explained as due to the mode of infection: the primary symptoms are the result of a virus infection from the soil directly into the tubers; whereas, the secondary tuber symptoms come from systemic infection.

In practically all potato plots, based on "spraing-tubers" as setts, a varying but usually small number of plants showing a special type of mosaic is to be found. Provisionally called "spraing-mosaic," this mosaic is very similar to potato stem mottle described by Rozendaal. There is an obvious, positive correlation between the mosaic symptoms on the haulmes and the occurrence of secondary spraing in the tubers.

Spraing-mosaic has been transmitted by means of top-grafting to potato and to a number of other solanaceous plants. Sap-inoculation has proven feasible from top-grafted tomatoes to tobacco, and from tobacco to other plants. All attempts to transmit the virus by sap-inoculation from potato to other plants so far have been in vain.

In two experiments top-grafted potato plants gave rise to tubers with internal brown necrosis. The symptoms could not be said to be typical spraing, but fell within the range of the possible variation of true secondary spraing symptoms.

All facts hitherto found are well consistent with the interpretation of spraing as a virus disease. From that point the causal connection between spraing, spraing-mosaic and potato stem mottle is discussed.

MOSHER, PAUL N.

PRODUCTION PRACTICES KEY TO POTATO QUALITY

Random samplings of about ten per cent of the Maine potato farms during the harvest season of 1956, 1957, and 1958 indicated that certain cultural production practices affect dry matter content of several potato varieties. In general, these mass data indicated that early planting, use of less fertilizer, and delayed vine killing were all contributing factors to higher dry matter and better colored potato chips. Survey data also indicated that Maine potato growers are rapidly approaching fertilizer rates and grades recommended by the Maine Agricultural Extension Service.

MURPHY, H. J. AND MICHAEL GOVEN

EFFECT OF TIME AND METHOD OF VINE KILLING AND DATE OF HARVEST ON YIELD, SPECIFIC GRAVITY, TUBER SKINNING, AND CHIP COLOR INDEX OF KATAHDIN AND RUSSET BURBANK POTATO VARIETIES

Quality and maturity studies conducted during 1957 and 1958 using the Katahdin and Russet Burbank varieties indicate that maturity of potatoes can be radically influenced by time and method of vine-killing. Regardless of seasonal influence on quality, proper manipulation of time and method of vine-killing can do much to improve quality as measured by specific gravity, tuber skinning, and chip color readings of harvested tubers. In general, tubers that are properly matured prior to harvest have a better general appearance, and are preferred by the processor and fresh-market consumer. Vine killing properly, also provides tubers that have better storage characteristics and grade out better when packed for shipment to market.

NIEDERHAUSER, JOHN S., R. W. BUCK, AND ROBERT V. AKELEY

ERENDIRA, A NEW BLIGHT-RESISTANT POTATO VARIETY FOR THE HIGHLANDS OF CENTRAL MEXICO

Erendira is a bushy, semi-erect, medium-late, white-flowered variety developed for growing as an unsprayed crop in Central Mexico. The tubers are round to oval, white-skinned, and with eyes of medium depth. Pale pinkish streaks are frequently seen in the white flesh of the tuber. This defect probably will limit the usefulness of this variety to small farmers who grow it as a basic food crop, and do not object to the coloration. The multigenic blight resistance of Erendira is sufficiently high to enable it to produce good to excellent yields in Central Mexico with no protective fungicide sprays. Erendira has yielded over 400 bushels per acre in unsprayed fields; all imported or local commercial varieties tested were blight-killed and yielded nothing.

Erendira is a seedling selection from a cross between U.S.D.A. Ac. No. 24891 x U.S.D.A. seedling X 528-170. Ac. No. 25891 sent to the U.S.D.A. by Dr. Wilhelm Rudorf, and was identified by him as a cross between two hybrids of *Solanum demissum* x *S. tuberosum*. X 528-170 is a seedling from a cross between Richter's Jubel and a hybrid seedling (S. 45537) of Chippewa x Katahdin.

NIEDERHAUSER, JOHN S. AND JAVIER CERVANTES

ANITA, BERTITA, AND CONCHITA, THREE NEW BLIGHT-RESISTANT POTATO VARIETIES DEVELOPED IN CENTRAL MEXICO

The blight-resistant varieties Anita, Bertita, and Conchita were developed in the potato breeding program of the Office of Special Studies, Mexican Department of Agriculture, for cultivation during the rainy season in Central Mexico. Their multigenic blight resistance permits the production of high yields even in unsprayed fields. Their adaptation and acceptance in other areas is being studied. Their characteristics are:

Anita: seedling from a self-pollination of a selection from U.S.D.A. Ac. No. 25953 x U.S.D.A. seedling B 2131-3. Plant tall, erect, vigorous, very late maturity; foliage dark green, thick stems; flowers abundant, light purple; tubers round, tending to oval; skin light-reddish color, flesh cream-colored, medium number of well-distributed deep eyes.

Bertita: seedling from a self-pollination of a selection from U.S.D.A. Ac. No. 25953 x U.S.D.A. Ac. No. 25959. Plant medium height, erect, medium maturity; foliage light green, well-developed; flowers white, few; tubers oblong, smooth, with cream-colored skin and creamy flesh; eyes superficial and few.

Conchita: seedling from a self-pollination of a selection from U.S.D.A. Ac. No. 25953 x U.S.D.A. Ac. No. 25959. (sister selection of Bertita). Plant medium height, erect, bushy, medium maturity; foliage light green; flowers white; tubers oblong, with cream-colored skin, yellow flesh, and few, semi-superficial eyes.

The parental material was sent to Mexico by the United States Department of Agriculture, and the self-pollinations were made there. The selections were made in the field at the Santa Elena Experiment Station, near Toluca, Mexico. Ac. No. 25953 and Ac. No. 25959 were sent to the U.S.D.A. by Dr. Wilhelm Rudorf, Germany, and are hybrids produced from *Solanum demissum*, *S. andigenum*, and *S. tuberosum*. B 2131-3 is a seedling produced in the U.S.D.A. potato-breeding program from a cross between B 56-1 anud B 594-46. It is a light red seedling possessing resistance to scab, late blight and virus A.

O'KEEFE, R. B.

FACTORS AFFECTING AND METHODS OF TESTING POTATO VARIETIES (*SOLANUM TUBEROSUM, L.*) FOR HEAT AND DROUTH RESISTANCE

Under field conditions root development differences among nine varieties apparently were slight as indicated by the consistency of time and rate of water extraction to soil depth of six feet independently of variety. All varieties obtained 53 to 61 per cent of the total extracted water from the top foot of soil. Total yield and total water extracted were directly correlated. Consequently even though statistically significant differences were obtained between variety yields, the variations in the production efficiencies (bushels per acre per inch of water) of the varieties were small and statistically insignificant.

Twelve distinct types of wilting curves were obtained in high temperature heat machine tests (132° to 134° F.) with the 45 varieties. Permanent plant damage and the degree of plant wilt were directly correlated. As the severity of plant wilt increased, permanent plant damage increased. Inherent maturity had little effect on the response of varieties to heat and the consequent and amount of permanent plant damage. The degree of plant wilt was statistically correlated to plant height and also to the coefficient of leaf area. The degree of wilt increased as plant height increased and as the magnitude of coefficient of leaf area decreased.

The coefficient of leaf area as determined by multiplying the number of leaves by the number of leaflets times the estimated leaflet size provided a reliable comparative estimate of total leaf areas.

The coefficient of leaf area as determined by multiplying the number of leaves by the number of leaflets times the estimated leaflet size provided a reliable comparative estimate of total leaf areas.

Water losses were determined from excised leaves, stems and intact plants of the forty-five varieties. Water loss from leaves was from 1.5 to 1.8 times the corresponding water losses from intact plants or stems. The volume of water lost per unit of leaf area was correlated to the coefficient of leaf area. As the magnitude of the coefficient increased, the volume of water lost per leaf unit decreased. The degree of plant wilt

as determined by heat machine tests was also correlated to and decreased as the magnitude of coefficient of leaf area increased. However, the degree of plant wilt was not correlated to the total (per cent) water lost from leaves. Consequently, the desiccating effect of heat and heat-induced drouth was concluded to be a result of the volume of water lost per unit area of leaf rather than the total percentage of water lost from the total leaf area.

PELOQUIN, S. J. AND R. W. HOUGAS

HAPLOIDY IN *SOLANUM TUBEROSUM* AND IN THE SUBSPECIES ANDIGENA

Numerous haploids derived from a wide range of *Solanum tuberosum* germ plasm are required if their value for breeding and genetic studies is to be adequately explored. Sixteen varieties and several breeding stocks of the common potato were used as females in inter-specific matings with 30 "pollinators" in attempts to obtain haploids. The combined use of suitable genetic markers and decapitation of the pistillate parent substantially increased the efficiency of detecting haploids. One hundreds and seventy-four new haploids representing 12 varieties and 5 breeding stocks were obtained.

The frequency af haploids per 100 pollinations ranged from 0 to 9. The choice of both the *S. tuberosum* parent and the "pollinator" had a significant effect on the frequency of haploids. Ten selections of *S. tuberosum* subsp. *andigena* were used in preliminary trials to obtain haploids from this subspecies. Twenty-eight haploids representing 6 *andigena* selections were obtained from 700 inter-specific pollinations.

PLAISTED, ROBERT L.

A TECHNIQUE FOR EVALUATING THE ABILITY OF SELECTIONS TO YIELD CONSISTENTLY IN DIFFERENT LOCATIONS OR SEASONS

One of the characteristics which influences the acceptance of a new variety by the growers is its dependability over a range of growing seasons and locations. A statistical technique has been developed which utilizes the information normally obtained from the regional yield trials in which a selection is usually tested prior to release.

Briefly, the technique is to compute a combined analysis of variance of all n varieties over all locations. If the variety x location interaction is significant, then a similar type of combined analysis is computed for each of the $\frac{1}{2}n(n-1)$ combinations of pairs of varieties over all locations. From these a component of variance, sigma VL^2, can be estimated for each pair of varieties. Next the arithmetic mean is obtained of the $n-1$ estimates involving one line in common. This then gives a figure which is defined as the relative contribution of that variety to the overall variety x location interaction component of variance.

The value of this technique can be assessed only as its results are borne out by the experience of growers with established varieties. Application of this technique to past yield trials in New York State showed that Green Mountain quite regularly had a high relative contribution to the interaction component while Katahdin and Cobbler had a low relative contribution. These results are in accord with experience with these varieties.

RIEMAN, G. H., D. C. COOPER AND P. M. TSENG

APPEARANCE AND DETECTION OF DIPLOID PLANTS (2x=24) IN SEEDLING POPULATIONS OF *SOLANUM TUBEROSUM*

Diploid plants (2x=24) of the common potato were obtained by examining the stomatal number and size of mature leaves from *Solanum tuberosum* plants from normal potato breeding populations. Approximately 100 small plants, one-half inch in height at transplanting time, were selected from 4,900 seedlings averaging about two inches in height. Four of these small selected plants formed mature leaves with twice as many stomata per given area as the non-selected tetraploid controls. Their stomata were smaller, the mean size being approximately half in volume (29μ x 23μ) that of the tetraploid controls (38μ x 27μ). Cytological examnations provided evidence that these four plants were *S. tuberosum* diploids with 24 chromosomes. The observed ratio of diploid to tetraploid plants was 1:1,225. Two of the four diploid clones flower readily, produce 25 to 40 per cent stainable pollen and form functional male and female gametophytes. Additional *S. tuberosum* diploids are being obtained from

normal plant breeding stocks by examining the stomatal condition of the cotyledonary leaves of seedlings grown from seeds of the smaller sieve sizes out of seed lots containing from 1,000 to 10,000 seeds.

SAWYER, RICHARD L. AND WILLIAM THORNE

USE OF ALCOHOLS FOR SPROUT INHIBITION

Several alcohols have shown promise as sprout inhibitors vaporized into forced air ventilating systems. Treatments are potentially inexpensive in comparison with materials now commercially available in the United States. With some of the lighter alcohols, vaporization into closed systems can give a serious problem of lenticel pitting if the concentration is not carefully controlled. A single application gives sprout inhibition for from 2 to 6 weeks on non-dormant potatoes depending on the alcohol used.

SILBERSCHMIDT, KARL M.

HISTORY AND RECENT OBSERVATIONS ON TYPES OF POTATO VIRUS Y NECROTIC TO TOBACCO

During the last year and the first months of 1959, in the Institute Biologico, Sao Paulo, Brazil, on several separate occasions, a strain of potato virus Y necrotic to tobacco White Burley has been isolated from samples of certain varieties (Augusta, Heida, Fina) of certified seed potatoes, imported into Brazil from Germany. The most striking symptoms were induced by this strain in tobacco White Burley, but by the usual mechanical methods we were also able to transmit this strain to *Nic. glutinosa, Nicotiana rustica, Petunia hybrida, Physalis floridana, Lycopersicum asculentum* and *Saracha jaltomata.*

In addition, by means of the insect-vector *Myzus persicae,* in a few but well studied instances, we succeeded in infecting seedlings of the potato variety Bona.

The first and preeminently practical conclusion refers to the need for a thorough inspection of the shipments of seed-potatoes, especially of determined varieties, imported from Germany and probably from other countries of Central Europe. However, there are several other problems to be solved which are of an equally high although more theoretical interest. One concerns the probable origin of the new strain of potato virus Y. Our interest in this question is rather understandable since, from potato samples obtained from the Andes, several strains of potato virus Y, necrotic to tobacco, have been isolated and described in our laboratory. These strains, as well as several others described by European research workers, had been believed to have arisen in South America. On the contrary, to the best of our knowledge, the new strain now prevalent in Central Europe, cannot be traced to a South American origin.

We consider as another point of interest the fact that the new European strain of potato virus Y was initially causing severe damage in the tobacco plantations and that only recently has its economic importance for the potato crop been recognized. Some strains of potato virus Y, according to our own observations, and the results recently published by G. D. Easton, R. . Larson and R. W. Hougas, fail to infect potato varieties considered susceptible to the standard strains of this virus.

VAN SLOGTEREN, D. H. M.

SOME RECENT DEVELOPMENTS IN INDEXING VIRUS INFECTED POTATO PLANTS IN THE NETHERLANDS

Since serological methods were first used for indexing potato virus X, their mass scale applicaion has also been extended to the potato viruses S and M. The greater part of these tests for the presence of viruses X, S and M combined in one single operation by mixing the respective antisera.

The serological microagglutination technique under paraffin oil is generally used, which is a modification of the slide agglutination test. This procedure has reduced the amount of antiserum needed per test to one thirtieth, and has about cut in half the time and labor involved.

In recent years the "Rippenbräune" strain of virus Y (evoking veinal necrosis in Tobacco) is spreading westward from Central Europe. Its semi-latent behavior in the potato plant has requisitioned serological indexing for virus Y.

In view of the fact that agglutination reactions with virus-Y-infected plants often require up to 3 hours to develop, the method under oil here has an essential advantage over the slide test.

Evaporation of the mixed droplets of sap and antiserum which causes a specific clumping of chloroplasts, is prevented.

Attempts have been made to apply the gel diffusion method in agar for indexing potato viruses.

A thin layer of agar is poured inside glass rings (ϕ 15 mm.) glued to the bottom of a petri dish. With a small corkborer a hole is punched in the center in which antiserum is pipetted. Crude sap of plants to be tested is pipetted in holes surrounding the center one.

Good results were obtained with plants carrying virus X, distinct sharp lines of precipitation being formed near the holes filled with sap. With other potato viruses the results so far have been unsatisfactory.

SMITH, ORA

EFFECT OF VARIETY, DATE OF HARVEST AND SOIL TEMPERATURE ON SPECIFIC GRAVITY OF POTATOES AND COLOR OF POTATO CHIPS

Nine varieties were grown and harvested at eight times between September 5 and November 20. The spcific gravity was obtaind at each harvest for each of the varieties and the color of chips was obtained also on day of harvest. These were related to the soil temperatures which prevailed during the week immediately preceding harvest. Lots of each variety from each date of harvest were stored at 40° and at 50° F. Specific gravity and sprout growth data were obtained and color of chips after several periods of storage.

Some varieties continued to increase in specific gravity later in the season than did others.

There is a close relationship between soil temperatures and chip color on day of harvest. Whenever soil temperatures at a depth of four inches go below 40° F. for several days or nights, dark color chips are produced from these potatoes.

After storaeg until April 1 at 50° darkest chips resulted from the later harvests. There were varietal differences in chip color after storage at 40 and 50° F.

SMITH, ORA AND R. H. TREADWAY

FUNCTIONS OF THE PROTEIN AND OTHER NITROGENOUS FRACTIONS OF POTATOES IN CHIP COLOR DEVELOPMENT

Studies were conducted with the following objectives, (1) preparation of potato protein fraction in sufficiently pure form for browning reaction experiments, (2) to determine the means by which potato protein fraction participates in browning reactions during chip frying and the relative reactivity of the protein nitrogen and the non-protein nitrogen and (3) to determine the extent of the browning reaction of the potato protein fraction with glucose, fructose and sucrose using a model system to stimulate conditions prevailing in chip frying.

By visual observation and by Rd readings of the Hunter Color Difference Meter it was found that neither the soluble nor the insoluble protein fraction participates to any degree in the browning reaction. Treatments that result in extensive browning reaction are those containing glycine with either glucose or fructose and to a lesser extent with sucrose.

SMITH, ORA

TREATMENT OF WHOLE AND SLICED POTATOES TO IMPROVE CHIP COLOR

Prestorage treatments consisted of immersing potato slices for 2 minutes in a solution of sodium bisulfite. Slices were stored at 40° and at minus 5° F. Periodically slices were fried and compared with the color and quality of chips made from potatoes of the same original lot which were stored whole at 40° F. and stored sliced, untreated at minus 5° F.

Light color chips were produced from sodium bisulfite treated slices held at 40° and at minus 5° F. for a month or two, whereas those stored whole at 40° for the same length of time produced dark chips. Storing sliced potatoes several weeks before frying results in an increase in blistering of chips.

Treating whole potatoes with SO_2 gas resulted in lighter color chips for as long as three months at 40° storage compared with whole, untreated potatoes stored at the same temperature.

STRUCHTEMEYER, R. A.

EFFICIENCY IN THE USE OF WATER BY POTATOES

From 1956 to 1959 inclusive a greenhouse study has been conducted during the

winter months studying the effect of different moisture tension on the growth of potatoes. The tensions used were measured by gypsum blocks. In some replicates tensions were the same throughout the entire growing period while in other replicates the tensions were varied during the growth cycle.

In general, the results of these greenhouse trials indicated that for maximum yields, soil moisture tensions of 50 per cent or above were needed. When tensions of 30 per cent and 15 per cent were allowed to develop, the growth of the potato plants was reduced.

THOMPSON, N. R.

INDUCED SEED FORMATION WITHOUT POLLINATION IN *SOLANUM TUBEROSUM* L.

Flowers of potato plants from which the style had been removed produced fruits when sprayed with 2 Methyl-4-chlorophenoxyacetic acid (MCP) at concentrations of .003 per cent to .006 per cent. A few of the fruits contained viable seeds. Cytological examination of the plants showed them to contain 24 chromosomes.

WERNER, H. O.

CHIP QUALITY AND DARKENING DURING DRYING WITH SLICES OF RAW DRY POTATOES AS INFLUENCED BY VARIETY, PLACE AND STORAGE

A statistically significant correlation coefficient of r=.37 was found between numerical estimates of chip color, made by aligning samples in a gradient series (1 darkest, 9 white) and Rd readings with a color comparator. The RC of Rd readings on color estimates was 4.54. With readings of grayness of dry raw slices of the same lots (1—black, 9 white) the correlation coefficient was .33 and RC of Rd on visual estimates was .74. Attention in a breeding program is being given to differences in darkenng of slices of raw dry potatoes because of the significance of that condition in prepeeling and processing.

Between tuber specific gravity and chip color, and to a lesser extent with graying of raw potatoes, there has been a high correlation within varieties, culture and places, the latter to least extent. Maturity, aside from is influence on specific gravity and post harvest storage have also been very important. A low but highly significant correlation was found to occur between chip color and raw tuber graying.

WHEELER, E. J.

POTATO RESEARCH AND DEVELOPMENT IN INDIA

Seven hundred thousand acres are utilized for growing potatoes in India. The yield has fluctuated from thirty-six to forty-two hundredweight per acre for the past ten years. Although potatoes were introduced into India sometime during the 17th Century, no extensive improvement was initiated until 1932.

The Indian Council of Agricultural Research established in 1929 recognized the need for research on the potato crop. Many projects were financed by the Government of India. A wide range of breeding material from many countries was collected and studied at Simla. Certification initiated studies on the survey of potato areas with regard to incidence of virus diseases and on the production of disease-free stocks of commercial varieties. The Central Potato Research Institute was initiated in 1949 with headquarters at Patna, Bihar State. In 1946 the headquarters of the Director, Central Potato Research Institute was shifted from Patna to Simla. The Patna station is important for research on the potato for the plains area. Many other stations are financed by the Central Government, and research and development of the potato is financed by States where the potato crop is important.

The problem of providing disease-free seed is of importance to India. The area for production of elite seed is limited to the high altitudes. The mountain slopes are steep, erosion is ever present, and the yields are low. The winter production of the main crop in the plains from September to April requires a cold storage for the seed produced on the plains.

The major time of potato production is in the drought season and irrigation is required for economical production. The water is supplied from well and ditches in many of the areas by Bullock or human efforts. Many Agricultural College graduates are engaged in potato production. The technological development of the potato crop in India is having a social influence on the agricultural development of India.

20-DAY FORECASTS OF LATE BLIGHT BEING MADE EXPERIMENTALLY

Scientists are attempting 20-day forecasts of infections of late blight, a serious fungous disease of potatoes and tomatoes in 11 North-Central States, the U.S. Department of Agriculture reported recently.

On an experimental basis, a limited number of 20-day forecasts are now being sent weekly by USDA's Agricultural Research Service to cooperators in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin. It is expected that the extended forecasts will be issued generally next season, replacing 7-day forecasts, which have been routinely dispatched since 1952.

Research-developed methods of evaluating long-range weather forecasts and data on temperature and relative humidity near plant foliage have made possible these extended forecasts of late blight infections. Late blight attacks generally occur when the temperature is 65 to 75 degrees and the relative humidity is 90 per cent or higher for 12 hours.

This improved method of forecasting was developed by Jack R. Wallin of the Agricultural Research Service and John A. Riley, Jr., of the U. S. Weather Bureau, in cooperation with the Iowa Agricultural Experiment Station. It provides ample time to inform growers that protective chemical sprays will be necessary on certain days to prevent late blight infections.

Currently used 7-day forecasts are based solely on interpretations of data on past temperature and relative humidity near foliage. And because observers cannot study every affected location, it is difficult adequately and quickly to predict late blight conditions for the entire North-Central area.

In the case of 20-day forecasts, predictions of weekly severity of late blight are made at locations known as weather-blight stations by study of temperature and relative humidity near plant foliage. This information from each station is sent to a regional office at Ames, Iowa, for evaluation along with extended weather outlooks, and a 20-day forecast is made for the North-Central States.

The forecast is dispatched weekly from the regional office to cooperating weather-blight observers, extension plant pathologists and horticulturists, and growers.

The method of analyzing weather information may be used to predict epidemic infections of other crop diseases, such as the cereal rusts, which require intermittent periods of high humidity and wet foliage to exist.

IN MEMORIAM — JOHN TUCKER

1883 - 1959

The man who was largely responsible for the origin of Seed Potato Inspection and Certification Service in Canada, in the person of John Tucker, passed away on July 10 at the home of his brother at Dundas, near Hamilton, Ontario.

Mr. Tucker organized and pioneered the work in Ontario, and later across Canada. He very successfully developed export markets for large quantities of seed potatoes from the Maritimes. He retired from the Canada Department of Agriculture in 1945, after having been in charge of the Seed Potato Certification in Canada since 1926. In the First World War he served as a seaman, and joined the Department of Agriculture in Ontario in 1918.

John Tucker was the first Canadian to serve as President of the Potato Association of America and served as a member of the Executive for a number of years. In 1951 he was elected an Honorary Life Member. For many years he judged potato exhibits at numerous leading potato shows in Canada and U.S.A. He judged and conducted the Boys and Girls' Potato Competition at the Royal Agricultural Winter Fair from the first Royal Fair until his retirement.

Forty-two years ago a preliminary survey was made throughout Ontario by the late Dr. Paul Murphy, to establish the possibility of producing potatoes at a high standard as regards virus diseases. This was followed by inspection and certification of fields coming up to the standards adopted at that time. Many of these fields were in Northern Ontario, and large quantities of Northern Ontario grown seed potatoes were shipped to Southern Ontario, as it was found that Northern seed surpassed all others in vigor. Following this discovery, large quantities of Northern seed were shipped to many of the central states in the U.S.A. For many years Mr. Tucker made an annual trip to the Atlantic Seaboard where he had trial plots established. From these he was able to point out that our Canadian seed often produced the best crops. He later travelled extensively in the United States, Cuba, Mexico, and Central and South America in the interests of seed potato sales from Canada.

In 1958 Mr. Tucker was honored by The Ontario Soil and Crop Improvement Association for meritorious service to Agriculture, in the presence of two original seed potato growers from Ontario; namely, S. E. Griffin, Acton, and A. T. Hartwick, Walford, who have had seed potatoes inspected and passed on their farms each year since the system was first established.

Mr. Tucker was married thirty-four years ago to Winnie Reeves, sister of George Reeves, present manager, Food Terminal Market, Toronto. Mrs. Tucker succumbed three weeks after marriage, as a result of falling off a chair when hanging a picture in their new home.

IMPROVED PROCESSSING HELPS WIDEN MARKETS FOR POTATO PRODUCTS, USDA REPORTS

Improvements to help widen the market for potatoes were reported by U. S. Department of Agriculture scientists on July 22 at the 10th Annual Potato Utilization Conference at Idaho Falls, Idaho.

The improvements include:

1. An experimental method of controlling blistering of potato chips — often a serious problem in the $500 million potato-chip industry.

2. A manufacturing change that eliminates the need, in making potato granules, of adding previously dried granules to undried potato mash.

3. Changes in making potato flakes (another dehydrated potato product) that reduce the chance that flakes may develop a pasty quality, permit denser packing of flakes than was previously possible, and insure long-life on restaurant and cafeteria steam tables.

The blister control and granule processing reports were made by C. E. Hendel of the Agricultural Research Service's Western Utilization Research and Development Division at Albany, Calif., and the potato flake report by Roderick K. Eskew of the ARS Eastern Utilization Research and Development Division at Wyndmoor, Pa., where potato flakes were developed.

Blistering of chips, Mr. Hendel said, can be controlled by heating the raw potato slices in water or a weak solution of a calcium salt at 130 to 150 degrees F. for four to five minutes before the slices are fried.

The granule improvement involves first cooking the raw potatoes, partially drying them on heated drums, holding them at a low temperature to induce granulation, mashing the potatoes while they are still cold, and finally drying them in a stream of hot air. This sequence does away with the need for adding previously dried granules to undried mash. The process has been tried on laboratory scale equipment, but further work is necessary to adapt it to commercial operations.

The potato flake processing steps outlined by Mr. Eskew include precooking potato slices for about 20 minutes at 165 degrees F., then cooling them in water before steam cooking. He explained that, in manufacturing any dried mashed potato product, many of the starch-containing cells are likely to be ruptured, and the soluble starch thus released causes the product to become pasty. Precooking gelatinizes the starch granules and weakens cell-cementing material, so that mashing can be done with a minimum of cell breakage. Cooling the pre-cooked slices makes the gelatinized starch insoluble so that, even if some of it is released by broken cells, it does not cause pastiness.

Packaging efficiency is realized because the modified procedure allows the potato flakes to be cut into much smaller particles than they used to be, without sacrificing the excellent texture of the product. Institutional users of potato flakes will benefit because of the length of time that reconstituted mashed potatoes keep their fluffy texture on steam tables.

The developments are all outgrowths of integrated programs of basic, applied, and developmental research at the ARS Western and Eastern laboratories.

The dehydrated potato industry now processes about 5 per cent of all potatoes used for food.

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progress
report...

ON THE USE OF CHLORO IPC* FOR POTATO SPROUT INHIBITION DURING STORAGE

Columbia-Southern is developing a new type of potato sprout inhibitor *for application during storage*. This will be the cheapest, most effective means of protecting potatoes from sprouting.

For the past six years, Columbia-Southern, working with leading agricultural specialists, has been searching for a practical, effective solution to potato sprouting. Extensive research indicates this new Chloro IPC formulation is the best answer.

The comprehensive schedule of tests, including tests to insure safe and harmless use, is now near completion. Columbia-Southern will shortly announce further details as soon as they're available.

*Produced under Columbia-Southern Patent No. 2,695,225

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